INVESTIGATION OF THE EFFECT OF FIBER EXTENSIBILITY, STRENGTH AND RELATED PROPERTIES ON FIBER BREAKAGE IN MECHANICAL PROCESSING OF COTTON

Final Report
of
Contract No. 12-14-100-7176 (72)

United States Department of Agriculture
Agricultural Research Service
Southern Utilization Research and Development Division
New Orleans, Louisiana

with the

Agricultural Experiment Station
Institute of Agriculture
University of Tennessee
Knoxville, Tennessee

28 April 1968

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ABSTRACT

Six cotton varieties were selected for their wide range of physical properties. These six varieties were exposed to modifications by five combinations of relative humidity and temperature, to surface modification by boiling in alcohol, and to modification of extensibility by treatment in 22% NaOH. Each cotton variety-modification combination was tested for moisture regain, density, x-ray angle, tenacity, elongation, impact strength, length, fineness, immaturity, and alkali centrifuge value with toughness as a calculated parameter. Surface properties were investigated by determining the coefficient of friction.

Additional treatment was made on the above modified cottons by crushing at three pressures (17,000, 50,000 and 150,000 psi) at each of three relative humidities (35%, 65% and 80%) and by mechanically working the cottons (passing through a granular card six times) at the same three humidities. Each of these treated samples was tested as described above for changes in physical properties.

Twelve of the original modified cottons (without mechanical treatment) showing a wide range of characteristics, especially extensibility, were processed into yarn and strength, elongation, abrasion, grade and spinnability measured. In addition, each of these cottons was tested for twisting and roping and torsional stiffness.

The results showed that cotton fibers were initially damaged by low humidity and by high temperature modification, especially when the two were in combination. The effect of this damage was evident when the fibers were exposed to compressive stresses. An even greater effect was seen when they were exposed to mechanical working action such as the card. It was also found that the higher relative humidities, 65% and over but below the limits of condensation, were desirable for least damage during processing and for best processing results. Some fibers which seemed to process well had low torsional stiffness even though low torsional stiffness increased the twisting and roping potential.

Upon removal of some of the surface waxes the fiber roughness was increased to a point that caused the fibers not to move adequately with respect to each other or properly through the processing equipment. This indicated that a maximum degree of surface roughness existed for optimum performance. A recently developed "shear friction" measurement was used to evaluate the interfiber action within a fiber mass.

NaOH modification increased fiber tenacity and elongation; however, other properties such as length were adversely affected so that consequent yarn properties were not desirable.

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28 April 1968

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The staff of our instrument shop in their untiring efforts provided equipment and special devices which were invaluable in the completion of this contract. They as well as our laboratory staff deserve a special vote of appreciation in their continued devotion to the program.

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LIST OF ABBREVIATIONS, SYMBOLS AND CODES

Abbreviations	Name	Units
A	Arealometer fineness	mm^{-1}
ACV	Alkali centrifuge value	%
D	Arealometer immaturity	mm^{-1}
E_1	Stelometer elongation (1/8 in. gauge)	%
F	Frequency of vibration	cycles/sec
I	Moment of inertia	g cm^2
Imp.	Impact strength(1/8 in. gauge)	g/tex
L	Length, single fiber	cm
	Length uniformity	%
50% SL	Digital Fibrograph 50% span length	in.
2.5% SL	Digital Fibrograph 2.5% span length	in.
L/P^2	Torsional stiffness value	cm/sec^2
P	Period of oscillation	sec.
T	Tension on fiber for linear density	g
T_1	Stelometer tenacity (1/8 in. gauge)	g/tex
T_1/E_1	Stiffness T_1/E_1	g/tex
Tou	Toughness $(T_1E_1)/2$	g/tex
	Roping method 1	%
	Roping method 2	lb/mg
	Yarn abrasion	cycles
	Yarn appearance grade	index
	Yarn elongation	%
	Yarn linear density	% C.V.
	Yarn strength	g
	Yarn strength variability	% C.V.
δ	Fiber linear density	tex
Γ	Torsional rigidity	dyne cm^2

LIST OF ABBREVIATIONS, SYMBOLS AND CODES (Continued)

Cottons	
C-1	Cal 7-8
C-2	Deltapine Smooth Leaf
C-3	Acala 4-42
C-4	Stoneville 7A
C-5	Pima S-2
C-6	Lankart 57

Modification	
1	35% RH-72°C 2 min.
2	65% RH-72°C 2 min.
3	80% RH-72°C 2 min.
4	35% RH-180°C 2 min.
5	65% RH-180°C 2 min.
6	Boiled in alcohol 3 hr.
7	22% NaOH
8	Control

Crushing Levels	
1	17,000 psi
2	50,000 psi
3	150,000 psi
4	No crushing

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SECTION I

INTRODUCTION

Characterization of cotton has long been the object of those who would attempt to predict the fiber behavior in mill processing and to project the end use value of the fibers. Another more recent problem has been the modification of the fiber character, intentionally or otherwise, which would affect its performance. This modification might be either before, during, or after processing and would usually cause eventual detriment to the fiber and to end product value. This investigation has attempted to discover more about how some of the atmospheric, chemical and physical modifications relate to fiber character and processing.

The total investigation included six cotton varieties selected for their wide range of properties (Table I). The cottons and their treatments and modifications in order are given in Table II. Twelve of the cottons which resulted from the modifications, that varied widely in their properties, were further evaluated in the spinning process by their yarn strength, yarn extensibility, yarn grade and spinnability (Table III). Each of these cottons were also evaluated for abrasion resistance, twisting and roping, and torsional properties.

TABLE I. The Six Cotton Varieties Used in the Total Investigation with Location Grown and Some of the Physical Property Values

Variety Code	Variety	Location Grown	X-ray Angle 40% degrees	X-ray Angle 50% degrees	Tenacity 1/8 in. Gauge g/tex	Elongation %	Toughness g/tex	2.5% Span Length in.	Fineness mm^{-1}	Immaturity mm^{-1}
1	Cal 7-8	Shafter, Calif.	29.9	26.6	22.1	6.2	0.69	1.07	446	28
2	Deltapine Smooth Leaf	Stoneville, Miss.	38.2	34.7	19.1	9.0	0.86	1.15	458	35
3	Acala 4-42	Shafter, Calif.	33.5	30.2	21.8	7.8	0.85	1.11	516	48
4	Stoneville 7A	Stoneville, Miss.	34.9	31.9	17.6	7.3	0.64	1.15	488	46
5	Pima S-2	Tempe, Arizona	29.8	26.9	30.3	9.0	1.37	1.36	495	34
6	Lankart 57	Lubbock, Texas	40.6	36.7	16.4	8.7	0.71	0.99	552	64

TABLE II. The Cotton Varieties with the Modifications, Treatments, Treatment Humidities and Fiber Parameters Tested

Variety Code	Cotton Varieties	Modification Code	Chemical and Atmospheric Modifications	Crushing Code	Mechanical Treatment	RH Code	Humidities for Mechanical Treatment	Parameters Tested
					Crushing			
1	Cal 7-8	1	35% RH 72°C	1	17,000 psi	1	35% RH	Density[1]
2	Deltapine Smooth Leaf	2	65% RH 72°C	2	50,000 psi	2	65% RH	Moisture regain[1]
		3	80% RH 72°C	3	150,000 psi	3	80% RH	X-ray[1]
3	Acala 4-42							
		4	35% RH 180°C	4	Not Crushed			Tenacity (T_1)
4	Stoneville 7A							
		5	65% RH 180°C					Elongation (E_1)
5	Pima S-2				Mechanically Worked			
		6	Alcohol boiled					Toughness
6	Lankart 57							
		7	22% NaOH		not mechanically worked			Impact strength
		8	Control					50% span length
					6 passes through granular card			2.5% span length
								Fineness (A)
								Immaturity (D)
								ACV
								Friction[2]

[1]Measurement of these parameters were made only on the modified cottons without mechanical treatment.

[2]Friction measurements were made on the control, NaOH samples and samples boiled in alcohol.

TABLE III. The Cotton Varieties, Modifications and Measured Parameters of Samples on Which Yarn Tests Were Made

Cotton Varieties	Chemical and Atmospheric Modifications	Yarn Parameters Tested	Fiber Properties
Cal 7-8	Control	Yarn strength	50% span length[1]
Deltapine Smooth Leaf	65% RH - $180^{o}C$ 2 min	Yarn elongation	2.5% span length[1]
Pima S-2	Alcohol boiled 3 hr	Yarn grade	Fineness (A)[1]
	22% NaOH	Yarn linear density	Immaturity (D)[1]
		Yarn abrasion	Alkali Centrifuge Value (ACV)[1]
			Fiber torsion[2]
			Fiber roping[2]

[1]These properties were measured on samples taken (1) before any processing, (2) after second drawing, and (3) at spinning.

[2]Fiber torsion and roping were tested on samples of each of the three varieties and four modifications with no processing beyond sample preparation.

The total investigation will be reported in four parts.

The effect of chemical modification and atmospheric changes on fiber properties.

The effects of high compressive stress at various humidities.

The effects of mechanical working at various humidities.

The effects of some harsh treatments on spinnability.

SECTION II

EFFECTS OF CHEMICAL MODIFICATION AND ATMOSPHERIC CHANGES ON FIBER PROPERTIES

Chemical modifications of and atmospheric changes on the mature fiber occur from weather in the field before harvest, (8)[1] in the gin by heat and moisture treatments, (7,9,22,26), in storage from internal heat generation and moisture changes, and in various chemical modifications surrounding processing which affect end use value (1,23,25). Selection of the atmospheric and chemical modifications for the cottons were made that might simulate treatments to which fibers could be exposed under actual situations as they moved from the field to the end product. A treatment where wax was removed from the fibers by boiling in alcohol was made to test changes in surface character. Structural modification that would permit a test of the effects of altered extensibility was made by a treatment in a 22% solution of NaOH.

Fiber Modifications

In 1964 ten cotton varieties were grown especially for this investigation by the USDA, ARS, CRD, Cotton and Cordage Fibers Branch. From these ten lots, the six which produced the widest range of characteristics were chosen and are shown in Table I, page 2.

[1]Numbers in parenthesis refer to references at the end of the report.

The raw stock sample of 15 to 25 lb was blended by placing 1 to 2.5 g pinches successively into 20 boxes. After the entire lot was distributed, the cotton in each box was thoroughly mixed. Cotton from all the boxes was recombined and baled for future sampling. Sub-samples were taken from the bale and initially prepared for testing by preparation of a 50 g multiple card web made by passing the cotton once through a granular card. The sample was collected in lap form on a drum so that the resulting lap was approximately 60 in. long and 8 in. wide consisting of 32 layers of card web as described by Landstreet, et al. (18).

The atmospheric modifications of Table II, page 3, were selected because they represented combinations of moisture and temperature which might be found, either in nature or in ginning, across the cotton belt. The cotton was conditioned for at least 24 hours at the specified humidity in a 72°F atmosphere before being heat treated. The heat modification was made at 72°C or 180°C by placing one layer of the lap for two minutes between grooved heavy aluminum plates in an oven that had been previously heated to the required temperature. Thermocouple measurements showed that less than a 20 second lag existed between the temperature of the plates and the temperature in the center of the sample from the time the sample was placed between the plates.

Another modification consisted of boiling the cotton in alcohol for three hours. This modified the fiber surface by removing part of the wax. Still another modification was made to affect fiber extensibility by treatment in a 22% NaOH solution. The sample was first saturated in a

0.4% wetting solution of Triton[1] at 86°F where it remained for 30 minutes. The NaOH solution was removed from the samples by a flowing bath of tap water at 85°F. The sample was then neutralized in a 1.0% solution of acetic acid for five minutes. After rinsing, the excess water was removed by blotting with paper towels; the sample was dried at 40% RH before conditioning at 65% RH.

Testing Procedure

Tests which were made on each sub-sample are shown in Table II, page 3. Standard instruments and test methods were used for all parameters except those for which no standard existed. Where no standard existed but proven procedures have been published, they were used. No adequate published procedures existed on impact tests and surface friction measurement; therefore, instruments and methods were developed especially for these experiments.

Each parameter was measured as described below:

Fiber density was obtained by the procedure described by Orr, *et al.*, (24) using a density-gradient column.

Moisture regain was determined by the method of ASTM Designation D 629-59T.

X-ray diffraction patterns were determined from films exposed on conventional equipment and evaluated on a modification of the densitometer described by Krowicki and Ewald (16). The modifications consisted of an adaptation which permitted the densitometer output to be amplified and

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[1]Mention of a trademark or a proprietary product does not constitute a guarantee or warranty of the product by the USDA, and does not imply its approval to the exclusion of other products that may also be suitable.

recorded on a strip chart recorder. The data, except as shown in Table I, page 2, presented 50% x-ray angle.

Strength and elongation were determined from the Stelometer at 1/8 in. gauge length. A Stelometer especially adapted for high elongation specimens was used for the cottons treated with NaOH.

Toughness was calculated from the Stelometer values (27) by the equation $(T_1 \times E_1)/2$.

Impact strength was determined from a device especially designed for this test (Figure 1 and Figure F-1). It was equipped for Pressley clamps at 1/8 in. gauge length. The force was transmitted to a counter-levered bar, the deflection of which was sensed by a differential transformer. The resulting signal was amplified and recorded on a strip chart. The time to break for this method, using a specimen adequate for a Stelometer type break, was approximately 1/80 second. To insure that the breaker and strip chart indicator were providing correct information, the breaker was equipped with a dashpot which, by means of a screw adjustment, permitted a large variation in the rate of application of force on the specimen. The variation in the time to break with this modification was from greater than one second to less than 1/100 second. It was found that, within the range of breaking speeds used in the experiment, the results were correct and repeatable.

Length - 50% and 2.5% span lengths were determined on a digital Fibrograph. The small samples obtained from some of the treatments required that the specimens be prepared by the hand-combed procedure as described in the method of ASTM Designation D 1447-66.

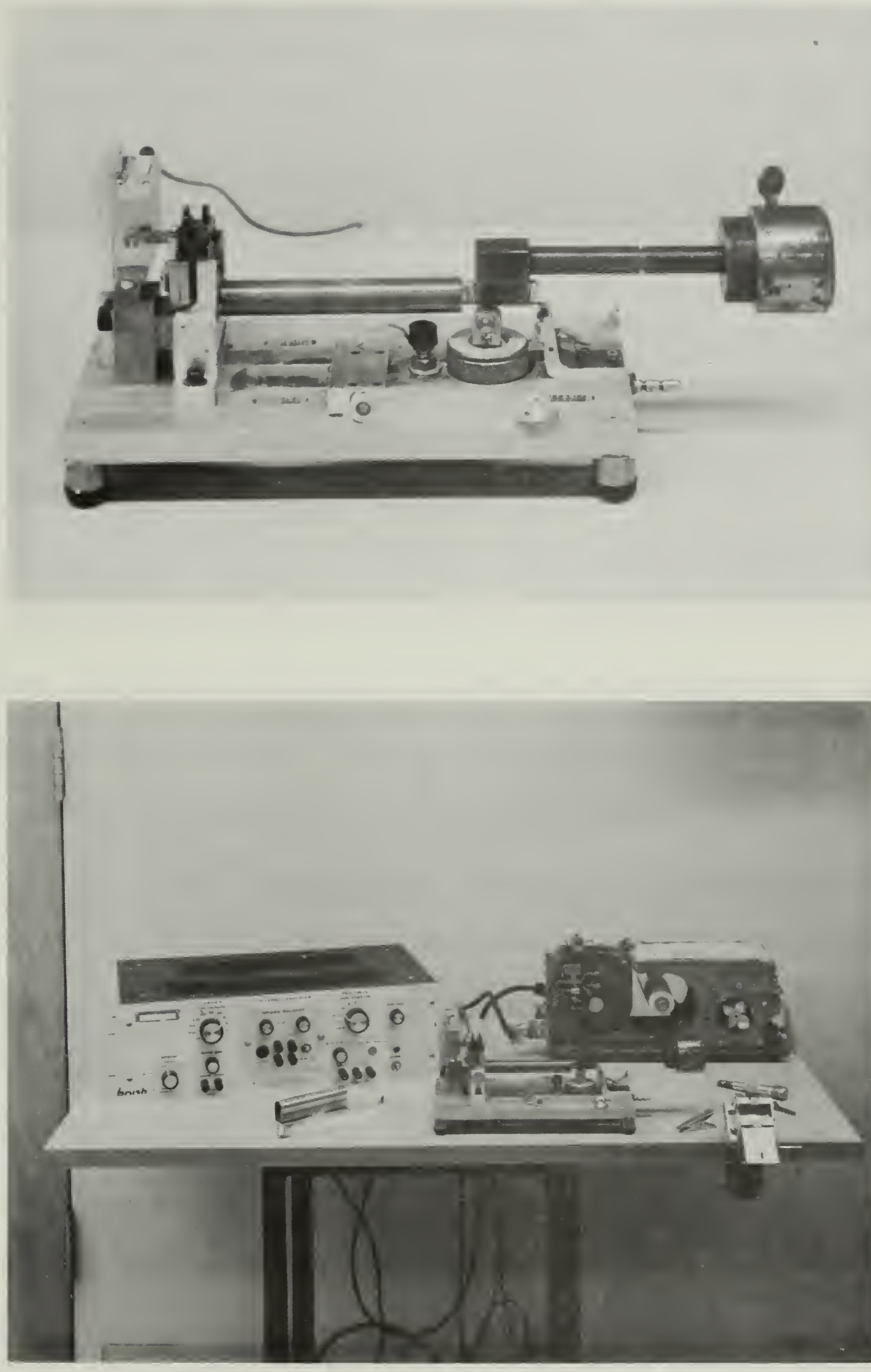


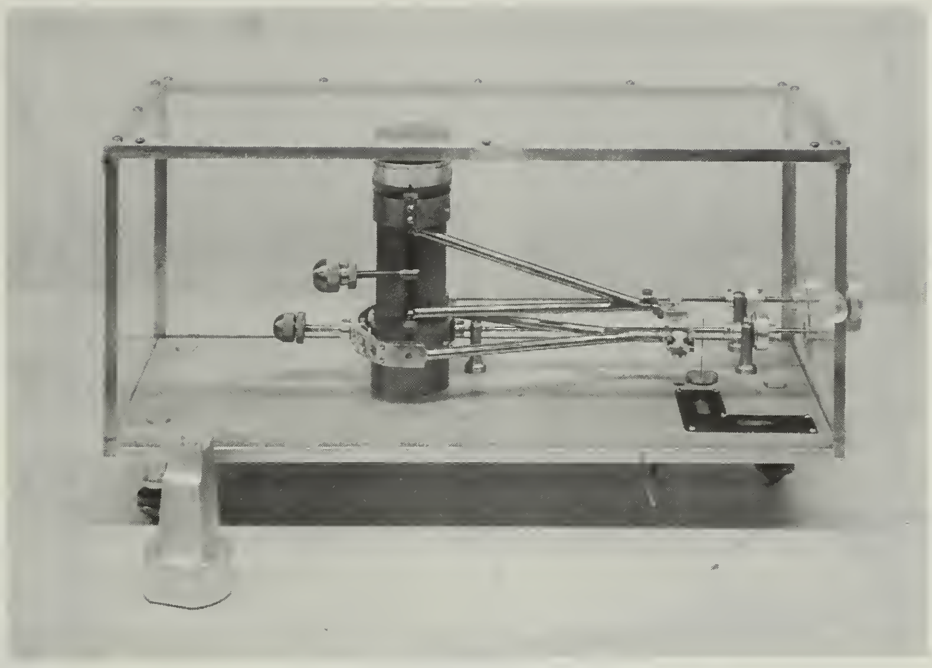
Figure 1. (a) Impact breaker, (b) impact breaker with accessories: amplifier strip chart recorder, comb, clip, vise and knife.

Fineness and immaturity were determined from the Arealometer. The values quoted are the specific area, A, and the immaturity, D, as described by Hertel and Craven (13).

Alkali Centrifuge Value (ACV) was evaluated by the technique developed by Marsh *et al*. (20). An increase in ACV from established control values is considered to be a measure of damage (17) although there are initial differences in ACV among cottons that cannot be attributed to fiber damage.

Fiber friction was determined from equipment especially constructed for this experiment and shown in Figure 2 and Figure F-2 and F-3. The specimen was prepared by placing a bundle of approximately 5 mg of fiber tightly over a flat surface. The specimen, when mounted on the instrument, could be pressed either against another specimen of fibers, similarly mounted, or against a plane glass or steel surface mounted in the same position that the second specimen would have been placed. The method and device for specimen preparation are shown in Figure 3. This permitted fiber to fiber or fiber to plane surface measurements. The instrument was equipped to provide a force normal to the specimen to specimen or specimen to plane surface contact which could be varied by a dial adjustment. A second dial adjustment could vary the force perpendicular to the normal force. After setting a specified normal force, the force perpendicular to the normal force was varied until the two surfaces moved with respect to each other. The coefficient of friction was taken as the ratio of the tangential force to the normal force.

A second method consisted of a horizontal plane placed on a disc rotatable about a horizontal axis (Figure F-4) upon which 1 cm square



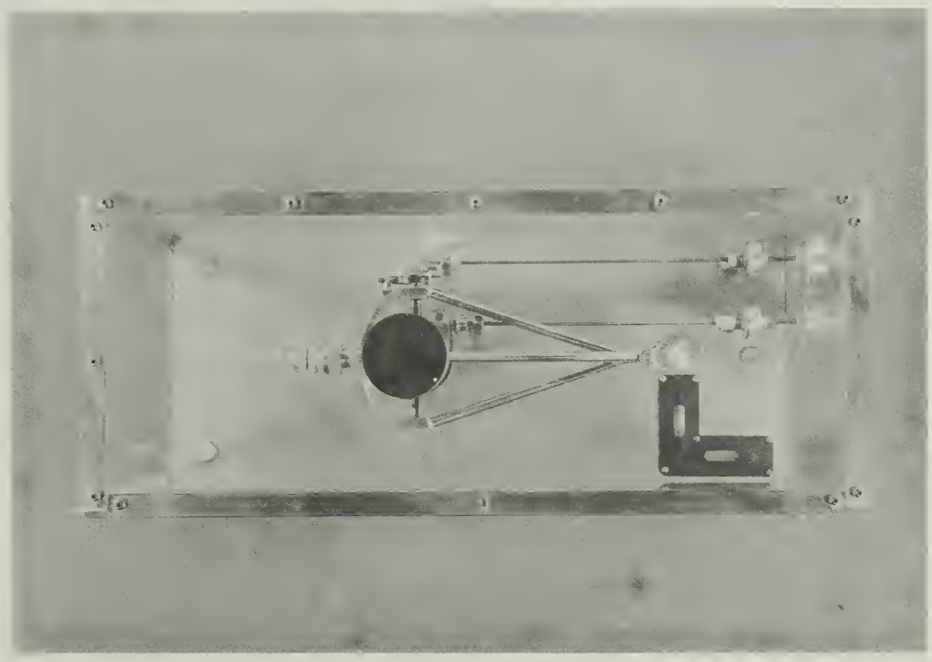


Figure 2. Instrument for determining coefficient of friction of fibers: (a) side view (b) top view.

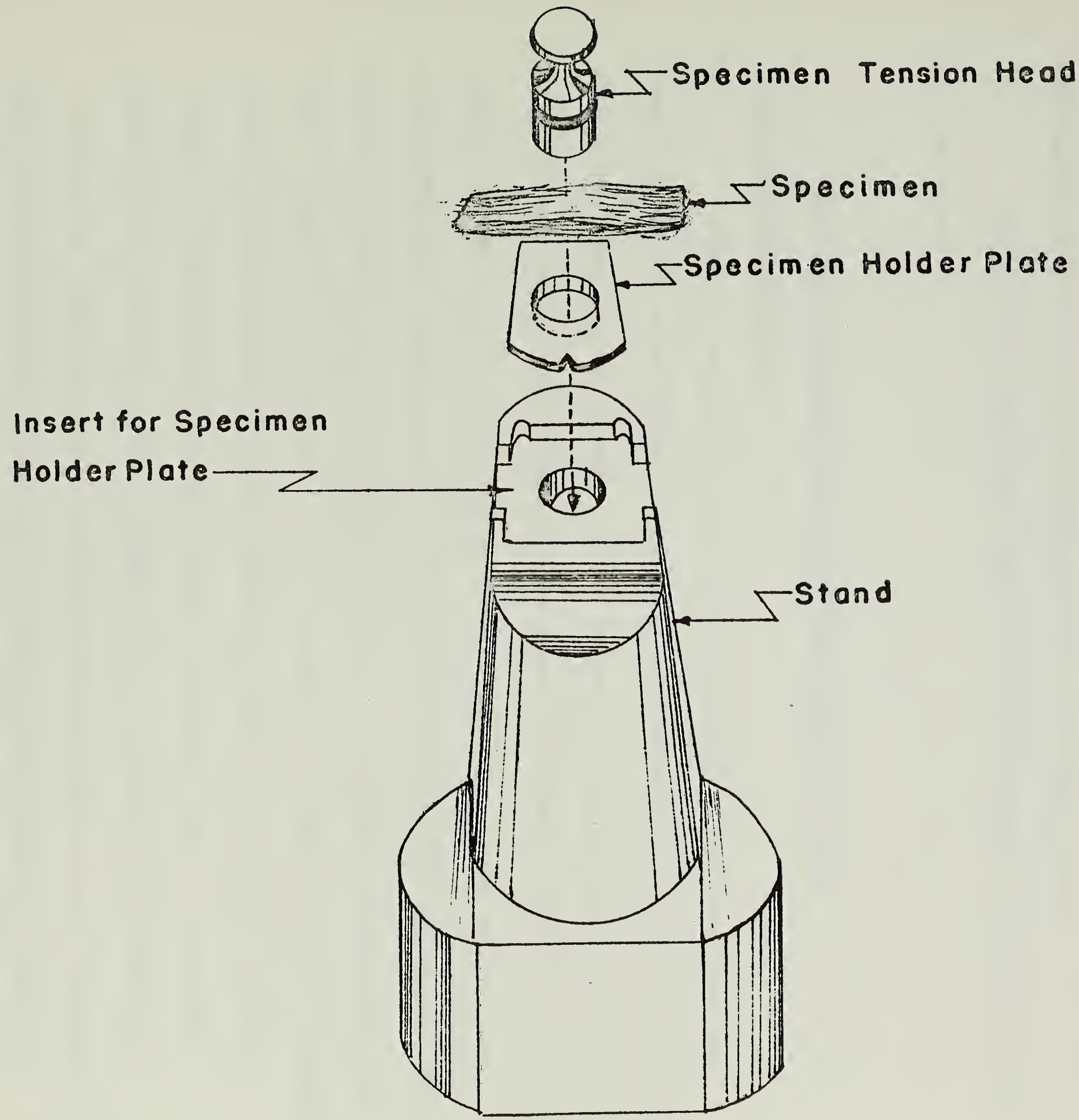


FIGURE 3 SPECIMEN PREPARATION DEVICE FOR THE FRICTION INSTRUMENT

cotton pads were tested over a wide range of loads. The disc was rotated until the cotton pads began motion and the coefficient of friction determined from the resulting angle of the horizontal plane.

Yarn tests which were made will be described in a later section of the report.

Results of Chemical and Atmospheric Modifications

Fiber property effects.

Density, moisture regain and x-ray diffraction patterns have been considered to be characteristics of fibers which relate to the internal structure. Density is related to the degree of crystallinity, the crystalline form and the state of amorphous cellulose. Moisture regain is also affected by the crystallinity in that the valence forces are less saturated in the amorphous material. In turn, x-ray diffraction patterns provide information on the orientation of the crystals. Thus, values in Table IV show that the crystallinity is greatly altered by the NaOH modification. (For the Duncan's range comparison see Tables A-II(a) through A-II(c)). Crystallinity is not greatly affected by any of the other modifications except the 180°C temperature. One possible exception is the effect of the high humidity modification as indicated by the density. These internal changes induced by the modifications shown in Table IV may possibly be related to the external physical properties.

It is interesting to note from Table A-I of Appendix A that the property means show a significant difference among almost all varieties

TABLE IV. Density, Moisture Regain and X-ray Angle for Each of the Six Varieties and Eight Modifications

Modifications	Cal 7-8	Deltapine Smooth Leaf	Acala 4-42	Stone-ville 7-A	Pima S-2	Lankart 57
		Density gm/cc				
Untreated	1.550	1.544	1.546	1.546	1.546	1.547
35% RH-72°C-2 min	1.549	1.545	1.546	1.546	1.546	1.546
65% RH-72°C-2 min	1.548	1.545	1.545	1.545	1.545	1.546
80% RH-72°C-2min	1.547	1.543	1.543	1.543	1.544	1.544
35% RH-180°C-2 min	1.549	1.548	1.548	1.547	1.548	1.549
65% RH-180°C-2 min	1.550	1.547	1.547	1.546	1.547	1.548
Alcohol boiled-3 hr	1.548	1.546	1.545	1.544	1.545	1.545
22% NaOH	1.522	1.516	1.519	1.518	1.522	1.514
		Moisture Regain Percent				
Untreated	7.31	7.13	7.48	7.56	7.13	7.40
35% RH-72°C-2 min	7.26	7.12	7.40	7.44	7.06	7.28
65% RH-72°C-2 min	7.28	7.13	7.41	7.47	7.18	7.35
80% RH-72°C-2 min	7.38	7.19	7.37	7.52	7.27	7.43
35% RH-180°C-2 min	6.80	6.68	6.93	6.93	6.64	6.98
65% RH-180°C-2 min	6.84	6.64	6.92	6.82	6.69	6.89
Alcohol boiled-3 hr	7.36	7.26	7.53	7.59	7.35	7.52
22% NaOH	10.40	10.31	10.58	10.53	10.21	10.27
		50% X-Ray Angle				
Untreated	26.6	34.7	30.2	31.9	26.9	36.7
35% RH-72°C-2 min	27.8	34.2	31.1	30.9	27.8	34.8
65% RH-72°C-2 min	28.3	36.1	32.2	30.9	29.2	35.8
80% RH-72°C-2 min	28.7	35.9	32.7	30.2	27.4	35.3
35% RH-180°C-2 min	27.9	34.9	31.9	30.6	28.5	37.9
65% RH-180°C-2 min	29.6	35.5	32.5	30.7	27.3	35.6
Alcohol boiled-3 hr	28.3	35.3	29.0	30.1	27.1	35.7
22% NaOH	24.2	30.5	26.8	25.2	21.1	27.4

Note: Each entry is the average of four readings.

for every property. This is as would be expected since the cottons were initially selected for their wide variations in fiber properties.

The tables of means (Table A-II) in Appendix A show that the NaOH modification which greatly affected the crystallinity, as indicated by the decreased density, increased moisture regain and decreased x-ray angle, affected each of the other measured fiber properties significantly. This is the expected result since the mercerization process chemically affects the cellulose crystallinity and orientation.

The modification of 80% RH and 72°C decreased the density of each variety. However, this did not seem to affect the other parameters measured.

The two modifications at the high temperature (180°C) caused the moisture regain to be significantly reduced. The change in internal structure as indicated by this reduced moisture regain definitely affected the tenacity of the fibers. The 35% RH and 180°C modification usually caused the most detriment. For most varieties both elongation and toughness (1/2 tenacity x elongation) were reduced by the high temperature treatments; however, the reduction was not significant at the 0.05 level.

The small reduction in the impact strength due to the atmospheric modifications was not significant for the individual varieties except for the 35% RH - 180°C modification on Pima S-2 variety. When all varieties were combined, the impact strength showed a significant difference due to 180°C heat modification.

Also, the 50% span length was significantly affected only at the 35% RH - 180°C modification on Pima S-2. However, for the means of all

the varieties combined, the 50% and 2.5% span length showed significant decreases for both high temperature modifications.

Fineness (Arealometer, A, value) was affected by the atmospheric modifications only with Cal 7-8 which increased with the 65% RH - 72°C modification and Acala 4-42 which decreased for the 65% RH - 72°C and 80% RH - 72°C modifications and increased for the 35% RH - 180° modification.

The atmospheric modifications did not significantly affect the immaturity value, D, of the Acala 4-42, Stoneville 7A and Lankart 57 varieties. The Cal 7-8, Deltapine Smooth Leaf and Pima S-2 showed appreciable scatter in the data as indicated by Table A-II(k) of Appendix A.

Table A-II(1) of Appendix A shows that the damage from the atmospheric modifications as indicated by the alkali centrifuge value has no particular pattern from one cotton to another except for the high temperature modifications. These were generally higher. The 35% - 180°C modification gave significantly higher ACV on Cal 7-8, Deltapine Smooth Leaf, Acala 4-42 and Pima S-2, with Pima S-2 showing the most damage. Note that the varieties which varied significantly in immaturity were in this same group. All varieties combined gave significantly higher ACV on the high temperature modification.

The modification by boiling in alcohol removed much of the surface wax. The effect on the surface was observed in the fineness, A, and the immaturity, D, values which are indirectly sensitive to surface characteristics. These data of Table A-II(j) and A-II(k) in Appendix A show that the apparent fineness, A, value was lowered significantly for all except two varieties and the immaturity was lowered significantly for all varieties. This is a similar effect to adding a surface roughner that

produces an apparent channeling in the Arealometer cotton plug and artifically reduces A. The elongation, E_1, was lowered for each variety while there was an increase in tenacity, T_1, for each variety except Pima S-2. This was probably due to better holding in the Pressley jaws (less slippage). It is interesting to note that there is very little change in the toughness value, $(T_1E_1)/2$, which is an indication of the energy to break. A reduction in length values was noted in all varieties treated with alcohol. This reduction was significant for four varieties for the 50% span length and for three varieties for the 2.5% span length. This reduction in length was probably accentuated by the breaking of fibers during the combing process in specimen preparation. Boiling in alcohol decreased the density for three varieties and increased it for one variety. The reduction may have been due to an increased volume of the fiber during boiling (possibly due to swelling of the lumen) which was not penetrated by the solution of the density column. It is especially interesting to note that the general significant effect on the varieties increased as the initial immaturity, D, increased and somewhat as the fineness increased.

The change in surface properties due to the modifications by NaOH and by boiling in alcohol was determined by the measurement of the coefficient of friction of cotton to cotton, cotton to stainless steel and cotton to smooth glass on the device of Figure 2, F-2 and F-3, previously discussed. Friction studies in this laboratory prior to these experiments had indicated that the frictional values obtained from sliding samples down a simple inclined surface correlated very highly with the air-flow fineness value. This led to the conclusion that the

coefficient of friction must vary with the normal force at each contact as previously reported by Bowden and Tabor (3). Table V shows the averages for each variety-modification combination and cotton-surface combination where the normal load was standardized at 6 g on a circular area of 0.307 in. diameter.

The statistical analyses of these data have shown the following significant differences. Cotton to smooth glass showed that the difference between modification means was significant but the difference between variety means was not. Cotton to stainless steel showed, again, that the difference between modification means was significant but not the difference between variety means. Cotton to cotton showed that the difference between both variety means and modification means were significant. These results seemed to be greatly affected by difficulty in perfecting specimen preparation and experimental techniques which could bring adequate reproducible results. This was indicated by the fact that the analyses of variance always showed a singificant difference due to replication.

There was a large variation among readings within a given specimen. Cotton to cotton seemed to give the widest scatter among readings of the same specimen but more plausible overall results. Cotton to glass and cotton to stainless steel seemed to vary less among readings of the same specimen but seemed to vary just as much from specimen to specimen as the cotton to cotton measurements. This led to the hypothesis that the distribution of the number and intensity of the contacts was more constant from one measurement to another within any one specimen but varied

TABLE V. Coefficient of Friction of Fibers from Six Cotton Varieties and Four Modifications for Three Methods of Testing

Modification	Variety: Cal 7-8	Deltapine S.L.	Acala 4-42	Stoneville 7-A	Pima S-2	Lankart 57	Modification Mean
(a) Cotton to Smooth Glass							
Control	.122	.111	.125	.127	.113	.113	.118**
Alcohol	.105	.130	.114	.114	.120	.125	.118
NaOH	.095	.103	.102	.104	.097	.102	.100
Variety mean	.107	.115	.114	.115	.110	.113	.111
(b) Cotton to Stainless Steel							
Control	.228	.215	.231	.218	.239	.224	.226**
Alcohol	.242	.230	.241	.248	.241	.225	.238
NaOH	.226	.226	.221	.233	.223	.231	.227
Variety mean	.232	.224	.231	.233	.234	.227	.230
(c) Cotton to Cotton							
Control	.203	.201	.186	.229	.171	.224	.202**
Alcohol	.230	.230	.255	.243	.229	.265	.242
NaOH	.204	.201	.200	.198	.182	.209	.199
Variety mean**	.212	.211	.214	.223	.194	.233	.214

**These means were checked by the analysis of variance and found to be different at the 1% level of significance.

among specimens. However, the distribution of values for the fiber to fiber surfaces covered a much wider range from one measurement to another within any one specimen but varied no more from specimen to specimen than did the cotton to plane surface measurements.

The results of the friction determination by the inclined plane method where the horizontal plane was attached to the rotatable disc are shown in the graph of Figure 4 for continuous runs. Continuous runs were used to ascertain whether the log-log plot was linear as claimed by Bowden and Tabor (3). It was concluded that it was only approximately linear. Figure 4 shows that the cotton boiled in alcohol has a lower coefficient of friction than the untreated. From the apparent roughness of the alcohol treated cotton along with the difficulty in processing it, one would predict that the alcohol treated should have the highest coefficient of friction.

Because of the difficulty in obtaining consistent friction data further work was initiated which dealt with surface properties in another way. Some of the developments which resulted have been reported by Hertel (11,12). The results of applying this new method to some of the cottons used in this investigation are given in a later section of this report.

Modification-variety interactions.

Figures A-1 and A-2 provide information regarding the interactions of the modifications, varieties and physical properties. Each graph shows the values of each parameter within each variety for each modification. Thus the relative level of each variety-modification combination may be observed for each parameter.

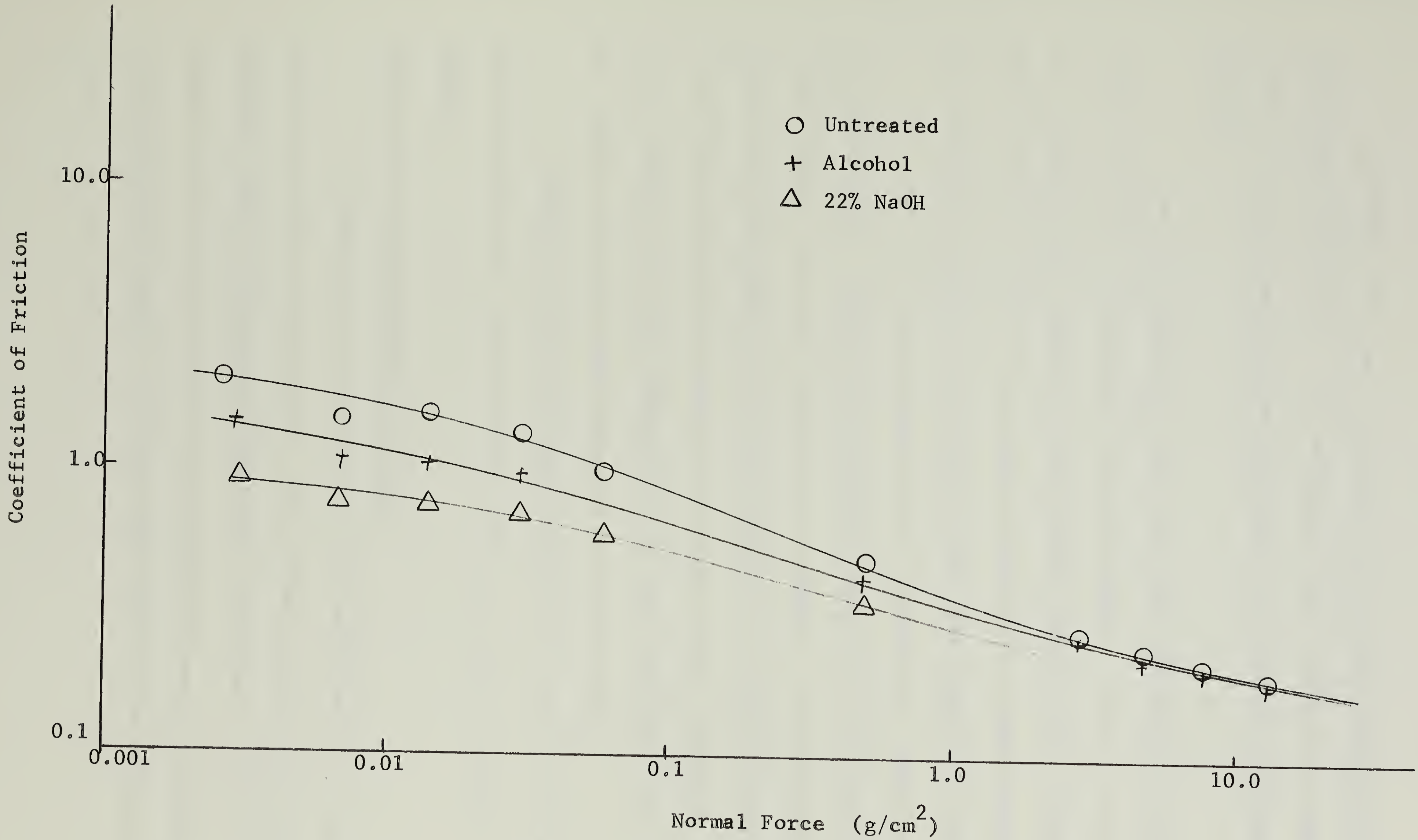


Figure 4. Coefficient of friction versus normal force over a wide range of normal forces for Cal 7-8.

Except for minor variations, the various modifications affected each variety similarly. The parameters which seemed to be most variable from one variety-modification combination to another were immaturity and ACV.

Pima S-2 stands far above the other varieties in toughness, impact strength, tenacity and the span lengths. It is a little lower in elongation than Lankart 57 and Deltapine Smooth Leaf. However, the high tenacity of Pima S-2 is enough to result in a high toughness value. The fineness of Pima S-2 is slightly lower than Lankart 57 and Acala 4-42.

Cal 7-8 is next below Pima S-2 in tenacity, impact strength and 50% span length. However, in elongation it is the low variety and, consequently, it is near the bottom in toughness. Even though it is second from the highest in 50% span length it is second from the lowest in 2.5% span length which results in a high length uniformity. Cal 7-8 is the coarsest and least immature of all the varieties. Also the ACV was lowest, indicating less damage by the modifications.

Lankart 57 had the highest elongation, ACV and fineness, the greatest immaturity, and the lowest tenacity, impact strength and span lengths.

Correlations among physical properties.

In addition to the effect of each modification on each of the parameters stated, each parameter was plotted against every other parameter and the correlation coefficient calculated. Observation showed that the results of the NaOH modification was so different that it controlled the results. The data were recalculated omitting the NaOH

modification and the resulting information is the basis for the following discussion. These correlation coefficients are presented in Table A-III.

The statistical significance of these data is academically determined by the number of paired values used in the calculation of the correlation coefficient. However, to give the correct weight to correlation coefficients here and in the other sections of this report, one must consider that there are one or more major sub-groups in each comparison and that in many cases a totally different relationship exists between the sub-groups as compared to the relationship within the sub-groups (see Hald (10)). This would almost make the relative significance of the correlation coefficients depend upon the nature of these sub-group relationships. Because of the grouped nature of the data within these sub-groups it would almost seem that the relative significance might sometimes be more closely determined by the number of appropriate sub-groups than by the total number of paired values. Another very important consideration in determining the true relevance of these correlation coefficients is whether the data meet all the assumptions required to make the comparisons valid. This should especially be applied to requirements of the two-dimensional nature of the variables and that the underlying population be normally distributed, which, in the case of some of the included data, may not be satisfied. The following discussion of the correlations is given with these considerations in mind.

Moisture regain was only notable correlated with density (-0.51) (see Table A-III). As initially discussed, both of these parameters are indications of the degree of crystallinity with a decrease in moisture regain as density increases.

Density was poorly correlated with all the other parameters. Its highest correlation was with elongation (-0.36). This plot was characterized by two groupings of points. The varieties were separated by elongation and the modifications by density.

X-ray angle had a high correlation with every parameter except toughness, density and moisture regain. This may be because x-ray angle represents the molecular orientation, a basic property of the internal structure. Each of the other properties measured was probably, to some degree, controlled by the molecular orientation. Even the x-ray angle-toughness plot shows that within a given species a high positive correlation exists with each variety in a separate conspicuous grouping. This is an observation that applies to most of the other graphs. In almost every case Pima S-2 was set off to one side of what would be a very good regression line for the other varieties. For most of the plots (x-ray angle and otherwise) Lankart 57 was positioned on the opposite extreme of the regression line from Pima S-2. This was especially pronounced on the x-ray angle-span length plots which are not included in this report. The 50% span length plot gave a nice picture of the negative correlation (-0.77); however, the 2.5% span length plot showed Pima S-2 and Lankart 57 at opposite ends of the plot ($r = -0.59$) with all other cottons grouped in the center with a low positive slope.

Impact strength seemed to be correlated very highly with each variable except elongation, fineness, density and moisture regain. The elongation and fineness plots were strongly affected by the values of Pima S-2 which had both elongation and fineness in a medium range and

a very high impact strength. Again the 50% span length seemed to separate the varieties in a more adequate way than did the 2.5% span length.

The correlations with 1/8 in. gauge tenacity by the Stelometer (T_1) gave a very similar picture to the impact strength. Again the correlations were extremely affected by Pima S-2. A comparison of the impact and T_1 strengths with the x-ray angle correlations shows similar patterns.

The correlations of elongation with the other parameters seemed to be affected by several factors associated primarily with the fibers before modification. Each variety on every plot was closely grouped with conspicuous separation according to elongation, as initially selected. The high elongations of Lankart 57, Deltapine Smooth Leaf and Pima S-2 always stood out. The unusual values of Pima S-2 caused it to be displaced from each of the other varieties in the plots. Though the modification by boiling in alcohol always caused a reduced elongation, it did not materially affect these plots. The high density of Cal 7-8 stands out on the elongation plot because of its low elongation and also because it matches with Pima S-2 in both moisture regain and x-ray angle, but not in density. The elongation-x-ray angle correlation is high ($r = 0.70$), and would have been much higher except for the displacement of Pima S-2. This is indicative of the relationship between the fibrillar orientation and elongation. Both impact strength and 1/8 in. gauge tenacity show almost no correlation with elongation. Both of these were strongly affected by the displaced values of Pima S-2, without which a higher negative correlation would have existed. The toughness-elongation

correlation (r = 0.56) would have also been higher. Length was poorly correlated with elongation. Fineness and elongation were well correlated and would have been more so except for the low A value combined with high elongation of Deltapine Smooth Leaf. The relationship of elongation to immaturity and alkali centrifuge value were both very good. However, in both plots there seemed to be two separate lines with each line having a very high correlation coefficient. One included Deltapine Smooth Leaf and Pima S-2 and another included all the other varieties.

SECTION III

EFFECTS OF HIGH COMPRESSIVE STRESSES AT VARIOUS HUMIDITIES

The true value of cotton fiber lies in its ability to be processed into a product of the required utility and durability. Among the desirable characteristics is the ability to withstand high compressive forces. This problem has been brought to the forefront more vividly in recent years because of the introduction of crush rolls at the card. These crush rolls are designed to crush the particles of foreign matter, thus, permitting the fine remains to fall from the web. It is assumed and tests have shown that this operation generally does not significantly affect the spinning process (4). The question, nevertheless, remains: What pressures will damage the fibers as determined by the fiber properties? It has also been of interest to determine the effects of compressive stresses on cotton which has been altered by atmospheric and chemical treatment.

A recent study has shown that the alkali centrifuge value increased very slightly with the use of crush rolls (14). The same study showed that the ACV increased approximately 10% as static pressure on a 0.6 g, 1 in. diameter sample was increased from zero pressure to 38 tons per square inch. It was also concluded that extreme drying at the gin did not make any apparent difference in the results of fiber tests.

This investigation has utilized six cotton varieties selected for their wide variation in fiber properties as previously discussed (Table I, page 2). These varieties were exposed to atmospheric modifications consisting of five combinations of two temperatures and three

relative humidities, a surface modification by boiling in alcohol, and a chemical modification by treatment with 22% NaOH (Table II, page 3).

The effect of these modifications on fiber properties has been previously discussed in Section II of this report.

Crushing Treatments

Each specimen was conditioned at the appropriate humidity after being cycled to that humidity from the high side. Figure 5 shows the ballast chamber (barrel) used for conditioning the specimens. The modified air was blown into the barrel, which was filled with cotton. The air was recirculated by the fan, shown attached to the barrel, and eventually moved up through the large upright tube and out through the smaller tubes onto which the specimens in plastic bags were attached. It was necessary to put a small hole in each bag so that the air could flow through. The humidity of the incoming air was modified until the appropriate humidity at the specimen was reached. Usually several days were needed to produce the correct equilibrium. However, after equilibrium was reached it was very stable.

The 48 modified specimens were each compressed in the cylinder shown in Figure 6. A 600 mg cotton specimen was placed into the 0.4205 in. diameter cylinder and the appropriate pressure applied.

Numerous tests were made to determine the best and most reproducible crushing method. The cylinder shown in Figure 6 and Figure F-5 with the Teflon heads produced the best results. A specimen that was crushed at the higher pressures with steel heads caused the cotton at the ends of

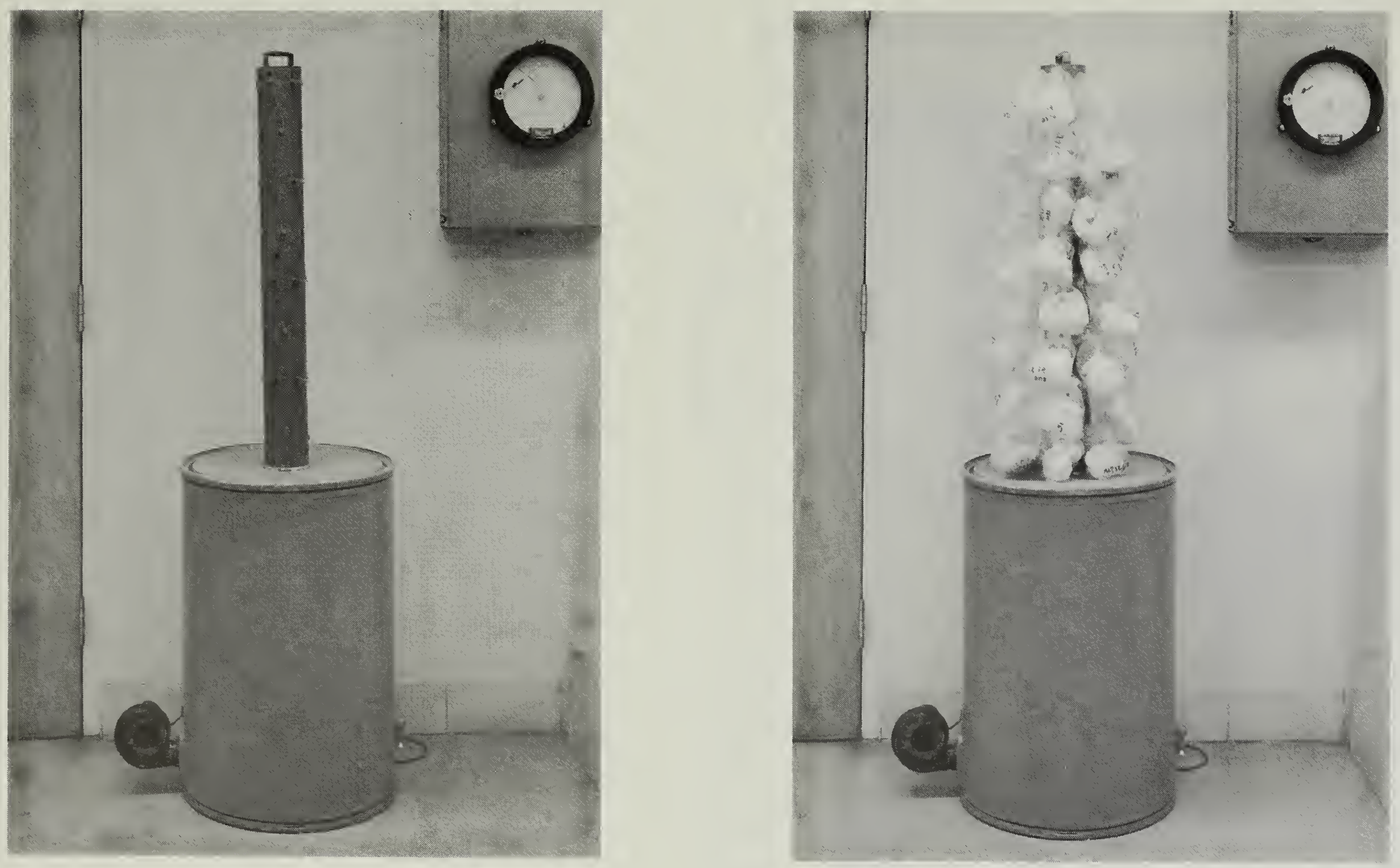


Figure 5. Apparatus for conditioning specimens (a) without apecimens, (b) with specimens in plastic bags attached to air excape nozzles.

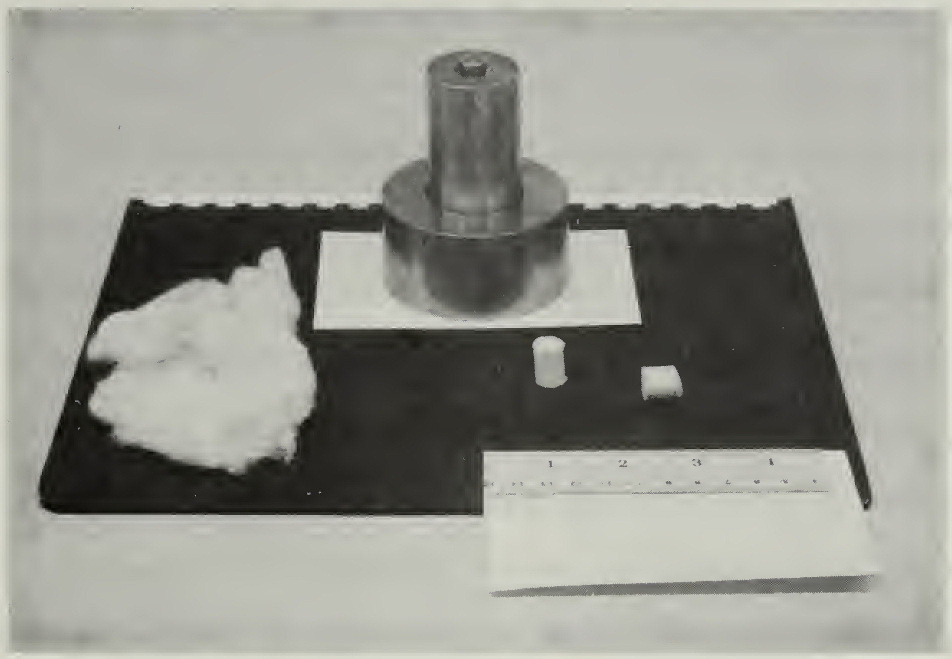


Figure 6. Crushing cylinder with two crushed 600 mg specimens in the right foreground and an uncrushed specimen in the left foreground.

the plugs to be powdered while the center of the plugs seemed to be affected only very slightly. The Teflon heads (0.067 in. thick) completely eliminated the powdering effect even at the very high pressures. A series of specimens were crushed at various pressures and the resulting strength values determined. These data are shown in Figure 7. Three crushing pressures (17,000 psi, 50,000 psi and 150,000 psi) were selected as the pressures to be used in this investigation. A specimen from each modified sample (Table II, page 3) was crushed at each of three relative humidities (35%, 65%, 80%). As the conditioned specimen was placed in the crushing cylinder in preparation for crushing, it was held under a small hood while a stream of air at the appropraite relative humidity was blown onto the area where the specimen was being handled.

Each specimen after compression was so compact that a standard method was established for opening and fluffing for minimum fiber alteration. The compact pellet was partially opened by exerting light pressure (less than 50 lbs) on it perpendicular to the direction in which it was initially compressed. It was turned 90° and pressure applied a second time. The specimen was then conditioned at 80% RH, cycled to 35% RH and then back to 65% RH so that each specimen approached the test humidity from the low side.

The parameters measured on each crushed sample are shown in Table II, page 3. The data are presented in the tables of Appendix D and the results of the analysis of the data are presented in the tables of Appendix B.

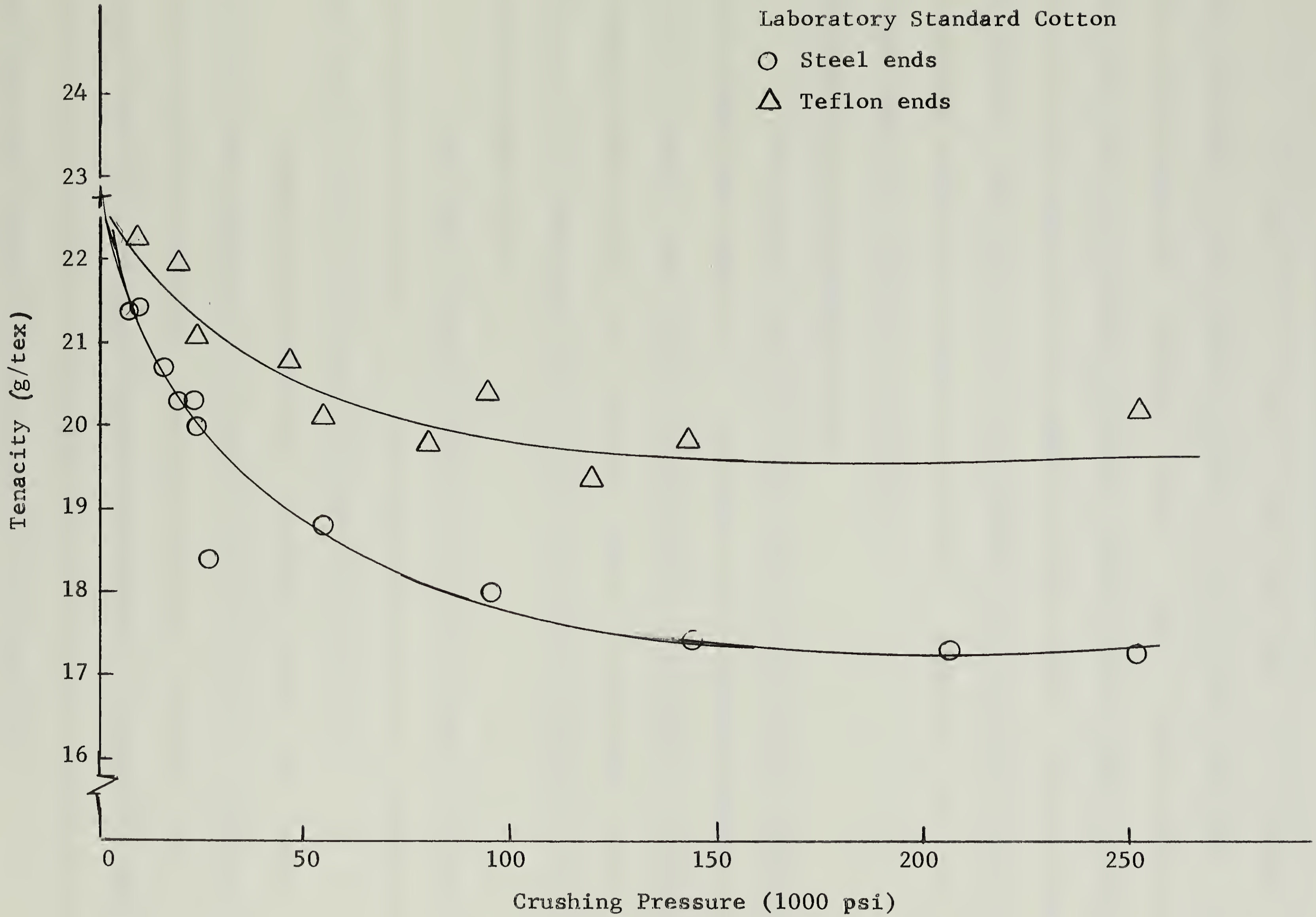


Figure 7. Fiber tenacity (T_1) for various crushing forces for the laboratory standard cotton.

Results from Crushed Samples

From Table B-I it may be noted that there are differences among most varieties as was expected because of the initial selection. It may also be noted that compared to Table I, page 2, these average values show that for the crushing treatments tenacity, span length, fineness value and the immaturity value have decreased and the elongation has increased. The effects on all the measured and calculated properties of individual varieties are shown in the data of Appendix D, and the Duncan's range comparison analysis in Appendix B.

Modifications and crushing levels.

The Duncan's multiple range test for the various parameters on the crushed data (Table B-II), providing the difference between modifications within a variety, tell almost the same story as the data on samples without crushing (Table A-II). In a very few cases the differences seem to be reduced by the additional data in this analysis as compared to that discussed in Section II.

The three crushing pressures all were different from each other with respect to tenacity. This was expected since this difference was the basis on which the crushing pressures were selected.

Elongation increased with crushing pressure. All levels of crushing were different in elongation from the control. Crushing level 1 (17,000 psi) was different from higher crushing levels for every variety except Pima S-2. Deltapine Smooth Leaf showed no difference between level 1 (17,000 psi) and 2 (50,000 psi) but did show a difference between the first two crushing levels and level 3 (150,000 psi).

The toughness value increased with the first two crushing levels but was reduced by the highest crushing level. This indicated that for all except the highest crushing level the effect of a decreasing tenacity was overbalanced by an increase in elongation. The control value was significantly lower than each of the crushing levels. In general there was little difference in the toughness values for the three crushing levels. However, for Cal 7-8 and Deltapine Smooth Leaf the value for the highest crushing level was signficantly lower than the lowest crushing level. In Pima S-2 the two higher crushing levels were significantly lower than the lowest crushing level.

The impact strengths for each crushing level are different except that levels 1 and 2 are not different for Stoneville 7-A. There is also no difference between the control and first crushing level for all varieties except Pima S-2 and Stoneville 7-A.

The 50% span length was generally increased by the first crushing level and decreased by crushing levels 2 and 3; however, for Cal 7-8 and Pima S-2 there was no difference in the control and first level. All varieties decreased in both 50% and 2.5% span length with increased crushing pressure. The 2.5% span length followed a pattern very similar to that of the 50% span length. However, except for Deltapine Smooth Leaf and Stoneville 7-A the 2.5% span length of the first crushing level was shorter than the control.

The Arealometer fineness, A, value showed a general decrease with crushing. The largest drop seemed to be from the control to the first crushing level with little drop after that even though some of the

differences were significant. Only Cal 7-8 showed a significant drop from the second to the third crushing level.

The Arealometer immaturity values were significantly different from the control to the first crushing level on all except Pima S-2. Acala 4-42 and Lankart 57 showed a difference between the first and second crushing level. No difference was shown on any variety between the second and third crushing levels.

A significant increase in ACV was shown from the control to the first crushing level. Four of the varieties continued to increase from the first crushing level to the second. No difference was shown between the second and third levels of crushing.

Crushing relative humidities.

The strength, elongation, toughness and length parameters were all lower at 35% than at 65% RH.

The tenacity values showed that no difference existed between the 65% and 80% RH except with the Acala 4-42 which increased at the higher humidity.

Elongation values were lower at 35% RH than at 65% RH with no difference shown from 65% RH to 80% RH.

Toughness values showed a difference among all relative humidities for Stoneville 7-A. The other varieties showed no difference between the 65% and 80% RH.

Impact strength values showed a difference among all relative humidities for Cal 7-8, Acala 4-42 and Lankart 57. The other varieties showed no difference between the 65% RH and 80% RH.

Both the 2.5% and the 50% span lengths increased with relative humidity for all varieties except Pima S-2. There was no difference in the Pima S-2 2.5% span length values between the 65% RH and 80% RH.

The fineness value, A, was reduced very slightly as the crushing humidity increased. Pima S-2 showed no difference among humidities. All other varieties showed a difference between the 35% RH and 80% RH but only Acala 4-42 showed a significant difference among all crushing humidities. No difference was found among the crushing humidities for the immaturity values.

ACV decreased as the crushing humidity increased. This decrease was significant between all humidities on all varieties except Deltapine Smooth Leaf (no difference between 65% RH and 80% RH) and Lankart 57 (no difference between 35% RH and 65% RH).

Interactions from crushing effects.

Interactions from the results of crushing are shown in the figures of Appendix B. Figures B-1 through B-6 show the relative effects of the various humidities and crushing levels on each variety using the average from all eight modifications. Figures B-7 through B-16 show these effects using the average of all modifications except NaOH and boiling in alcohol. The interaction effect may also be seen from the combined examination of Tables D-II(a) through D-II(i). The graphs were drawn for some of the data which seemed more outstanding.

The reduction of tenacity and impact strength is similar in all varieties. It is especially interesting to note that most of the varieties had a greater reduction in strength for the first crushing level (17,000 psi)

at 65% RH than for any other relative humidities (Figures B-1 and B-2). Both higher crushing levels for all varieties had the greatest strength reduction at 35% RH and the least strength reduction at 80% RH. Except for minor variations, elongation followed a pattern which showed greater elongation at higher humidities for all varieties and crushing levels. The resultant effect on toughness was that for all varieties and crushing levels, except the control, the 35% RH data were low and the 80% RH data high.

Length uniformity was decreased as crushing level increased and relative humidity decreased. The 50% span length was reduced more drastically than the 2.5% span length at the 35% RH and high crushing levels.

Immaturity and fineness both decreased as crushing level was increased and relative humidity decreased. However, a large drop was caused by the 17,000 psi crushing level with only a small change at the higher crushing levels. The fineness decrease was accompanied by an increase in ACV. Crushing caused less change to fineness on Pima S-2 than with any other variety. The greatest fineness change was with Lankart 57.

Figures B-7 through B-16 show clearly the change in level of the values as a result of omitting the NaOH and samples boiled in alcohol. Although this set of graphs shows some variations not shown in the graphs for all eight modifications, the trends shown from the effect due to crushing level are the same. Also, the relative order of the data with respect to the treatment humidity is the same.

<u>Correlations among physical properties</u>.

Correlations among the physical parameters of the crushed samples were made. Because the data from the NaOH and alcohol boiled samples were

so different from the other data, a second correlation was determined omitting data from these two modifications. These data are given in Tables B-III through B-IX. Table B-IX provides the correlation coefficients for all varieties combined and shows the effect of the modifications by NaOH and alcohol on these correlations. Although some of the correlations were changed very little by omission of these two modifications, others were almost reversed. This may also be seen from the correlations obtained from each of the cottons separately in Tables B-III through B-VIII.

If Table A-III (no crushing) is compared to Table B-IX(b) (with crushing) it may be seen that these correlation coefficients are very comparable except those for fineness, immaturity and alkali centrifuge value. It has already been observed that the fineness value decreased with crushing. This seems to have caused the drastic changes in the way both fineness and immaturity have correlated with the other parameters.

Since the NaOH and the alcohol modifications caused such variation in the correlations, the remainder of this discussion on correlations will be given on the basis of the six remaining modifications. Both impact strength and tenacity (shown in Tables B-III through B-VIII) are correlated negatively with ACV in all varieties tested, with the higher correlations being found in Pima S-2 and Cal 7-8. These correlations in Lankart 57 were almost zero. Impact strength showed little correlation with immaturity value. However, the tenacity-immaturity correlation was slightly higher. Almost no correlation was shown between impact strength and fineness, although the tenacity-fineness correlation with every variety was in the area of -0.50. Note from Table B-IX(b) that

when data from all varieties were combined both these correlations were zero. Both impact strength and tenacity were strongly correlated with 2.5% and 50% span length in most all varieties. The correlation with 2.5% span length was always slightly higher than with 50%. The lowest of these correlations was in Stoneville 7-A, with Deltapine Smooth Leaf being next higher. The impact strength-toughness correlation was low (positive) and the tenacity-toughness correlation was lower--near zero in Pima S-2, Stoneville 7A, and Acala 4-42. For Cal 7-8 this correlation (tenacity-toughness) was negative. From Table B-IX(b) it may be seen that when all varieties are combined, both impact strength-toughness and tenacity-toughness are strongly correlated positively.

Since toughness is a function of tenacity and elongation, these relationships must also be examined in the light of the elongation relationships. The elongation-impact strength correlation was low for all varieties. It was positive for Acala 4-42 and Stoneville 7A and negative for the other varieties. The elongation-tenacity correlation was negative for all varieties with a value ranging about -0.50. The highest correlations were for Cal 7-8 and Pima S-2. The elongation-toughness relationship was high in each variety, approaching 0.90. Thus, even though toughness is the product of tenacity and elongation, its correlation with tenacity in the crushed samples for the individual varieties was almost lost, while its correlation with elongation was increased. Both of these correlations were high with all varieties combined both in the crushed and untreated samples (Tables A-III and B-IX(b)).

Elongation was most strongly correlated, negatively, with span length in Cal 7-8. This correlation varied with the other varieties. In each variety the elongation-50% span length correlation was always less negative or more positive than the elongation-2.5% span length correlation. The reverse of this was found to be the case when data from all varieties were combined (Table B-IX(b)). The elongation-fineness and elongation-immaturity correlations were negative with all varieties with the fineness correlation usually being higher. The elongation-immaturity correlation from Pima S-2 was almost zero. When all varieties were combined, these two relationships gave positive correlations. The elongation-ACV correlation varied around 0.35 for Acala 4-42, Stoneville 7A and Cal 7-8. It was lower for Pima S-2 and Deltapine Smooth Leaf and was near zero for Lankart 57.

Toughness correlated well with 50% span length for all varieties except Acala 4-42 and Cal 7-8. The highest of these correlations was for Deltapine Smooth Leaf. The toughness-2.5% span length followed a similar pattern; however, it was much lower for all varieties and was near zero for Stoneville 7A. When all varieties were combined, the toughness-2.5% span length correlation was higher than the toughness-50% span length correlation. Toughness-fineness correlations were all highly negative. The lowest of these correlations was for Pima S-2. When all varieties were combined, the correlation was a low positive one. The toughness-immaturity correlations were negative but somewhat lower than the toughness-fineness relationships and was near zero for Pima S-2. With all varieties combined, the correlation was still negative but low.

The toughness-ACV correlations were all low with a positive relationship for some varieties and negative for others. Pima S-2 had the most negative correlation.

The 50% span length-fineness correlation was low for all varieties and near zero for Acala 4-42 and Pima S-2. It was positive for Cal 7-8, but negative for Deltapine Smooth Leaf, Stoneville 7A and Lankart 57. The 50% span length-immaturity correlation was low for all varieties varying from positive to negative Both of these correlations with all varieties combined were negative and higher than when each variety was considered separately. The 50% span length-ACV correlations were near zero or negative for all varieties. For Cal 7-8, Acala 4-42 and Pima S-2 this correlation was relatively high.

The correlation of 2.5% span length with both fineness and immaturity was near zero for Deltapine Smooth Leaf and Lankart 57 and somewhat low for the other varieties. These relationships were highest for Cal 7-8 and Acala 4-42. The 2.5% span length-ACV relationship was strongly negative except for Stoneville 7A and Lankart 57 where it was near zero.

Fineness and immaturity were strongly correlated positively except for Pima S-2 where the correlation coefficient was -0.20. Fineness-ACV correlations varied around 0.30 except for Pima S-2 and Lankart 57 where they were near zero.

The ACV-immaturity relationship was negative and low except for Cal 7-8 where r = -0.42. When all varieties were combined, this relationship became positive.

<u>Comparison of crushing effects</u>.

Crushing affected the measured parameters as indicated by Tables D-I through D-VI. Table VI shows the relative effects on the various varieties. Crushing altered tenacity, impact strength and the span lengths more strongly within the alcohol boiled sample than within any other modification. This was also true for elongation and ACV for Cal 7-8, Deltapine Smooth Leaf and Acala 4-42. Crushing within the alcohol modification did not affect elongation and ACV as much in the remaining three varieties.

With one minor exception, the least alteration due to crushing for all parameters within all varieties was within the NaOH modification.

Excluding the NaOH and alcohol modifications, the most drastic alterations were usually found for the samples treated at 180°C. A special exception to this was the ACV where the maximum alteration was not tied to any one set of modifications.

Cal 7-8 was affected most by crushing as indicated by the totals of the ratings in Table VI, and Lankart 57 was affected least. Even though small variations existed from one variety to another in the alteration due to NaOH treatment for the various parameters, the changes were all so near zero it would be difficult to say that one variety reacted differently from another. The alcohol modification made the smallest change in the span lengths due to crushing in Lankart 57 and the highest in Cal 7-8 with Pima S-2 as a close second. The 50% span length was always affected much more than the 2.5% span length. Crushing made only a very small change in the elongation of the alcohol modified samples. Crushing of the alcohol modified samples reduced tenacity more in Lankart 57 and least in Stoneville 7A.

TABLE VI. The Relative Rating of the Cotton Varieties According to the Effect of Crushing on Some Parameters[1,2]

	Cal 7-8	Deltapine Smooth Leaf	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57
T_1	6	4	3	1	5	2
E_1	6	1	4	5	2	3
Imp. St.	1	3	6	5	2	4
50% S.L.	6	2	5	1	4	2
2.5% S.L.	6	2	5	2	2	1
ACV (increase)	2	6	1	2	2	2
Totals	27	18	24	16	17	14

[1]Lower numbers indicate less alteration of the indicated parameter due to crushing as compared to the control.

[2]These ratings do not include the NaOH and alcohol modifications.

SECTION IV

EFFECTS OF MECHANICAL WORKING AT VARIOUS HUMIDITIES

The successful processing of cotton fibers depends upon their ability to be separated and placed together again in a uniform parallel arrangement which will be favorable for spinning a smooth even yarn. The accomplishment of this presently requires that the fiber be severely worked by almost every conceivable type of force. Simulation of this action was obtained by processing the fiber through a granular card. Mechanical action of this type has been previously investigated by Andrews *et al*. (2) and Honold and Brown (15).

Mechanical Working Procedure

The total mechanical working treatment consisted of taking the initial 50 g sample, as previously described in an earlier part of this report, and passing it through a standard granular card six times (18). Each time the sample was collected in lap form--8 in. wide on a 60 in. circumference drum with approximately 32 webs per lap. Table II, page 3, lists the cotton varieties, modifications and treatments, which were the same as those for the crushing tests.

The mechanical working treatment was made at three different humidities as shown in Table II. The 35% RH produced much fly in the card room with a web that was very difficult to control. Carding at 80% RH was also difficult. The dampness in the card room caused fibers to stick

where ever they touched and, in several cases, caused the cotton to hold to the card so that it was difficult to completely clear it of the particular sample being processed. The 65% RH treatment produced normal difficulty.

No additional abnormal carding difficulty was encountered due to the atmospheric modifications. However, the samples which had been modified by treatment with NaOH and by boiling in alcohol seemed to develop problems in the carding process. The NaOH treated samples produced a card web which held together very loosely and sometimes fell apart. The web had alternately thick and thin portions, although there was no outward indication of the fibers having difficulty in moving through the card.

The samples boiled in alcohol moved through the card with great difficulty. As the fiber moved through the card, a sawing sound was produced similar to that of a wood saw. Much of the fiber was held in the wires of the card and would not release even after continuous running of the card. The web was uneven with many neps and larger balls of fiber.

The parameters measured on each mechanically worked sample are shown in Table II. The data are presented in the tables of Appendix D and the results of the analysis of the data in the tables of Appendix C.

Results From Mechanically Worked Samples

The difference previously shown among varieties again comes out in Table C-I for each parameter measured. The only exceptions are that: (a) the elongation of Lankart 57 and Deltapine Smooth Leaf are not different; (b) the 2.5% span length of Stoneville 7A and Deltapine Smooth Leaf are not different; (c) the immaturity of Pima S-2 and Deltapine Smooth Leaf are not

different; and (d) the ACV of Acala 4-42 and Stoneville 7A and that of Pima S-2 and Deltapine Smooth Leaf are not different.

Modifications, mechanical working levels and relative humidities.

Tables C-II(a) through C-II(i) provide the results of the Duncan's range comparison between modifications, levels of mechanical working and humidities for mechanical working within each of the varieties.

The tenacity means showed that only small differences which were not significant except for Pima S-2 were evident between the 72°C modification and the control. However, the 180°C modifications show significantly lower tenacities than the other modifications for all varieties. Within Pima S-2 the alcohol modification gave the highest tenacity. For the other varieties except Deltapine Smooth Leaf the NaOH modification gave the highest tenacity with the alcohol modification being next highest. The mechanical working data as well as the data previously discussed in earlier parts of this report have shown that all the varieties except Pima S-2 tend to increase in tenacity after being modified with NaOH. The other varieties are affected to various degrees but all have a tenacity increase with NaOH modification. The increase of the tenacity for the samples boiled in alcohol did not show up in the crushed samples (Table B-II(a)); however, there was a slight indication of this in the samples without mechanical treatment (Table A-II(d)). The alcohol modification would probably have a slightly higher tenacity due to its increased holding in the jaws of the Pressley clamps from the change in surface characteristics. The alcohol modified samples which had been mechanically worked probably had a greater number of the weak fibers broken as a result of the fibers holding

to the card clothing as previously described. Thus, the fibers which remained were the stronger of those initially in the sample.

The tenacity for the mechanically worked was higher than that not mechanically worked on all varieties except Pima S-2, possibly because the weak fibers were broken in the carding process.

Two varieties showed no difference in tenacity at the three humidities. The other varieties had higher tenacity at 80% RH and in general decreased with decreasing humidity. Cal 7-8, Acala 4-42 and Pima S-2 showed no difference between 65% RH and 80% RH while Cal 7-8, Acala 4-42 and Stoneville 7A showed no difference between 35% RH and 65% RH.

The comparison of tenacity with impact strength shows much similarity. However, there is very little or no difference between the control and the alcohol modification, and the NaOH modification always produces the highest impact strength. For Lankart 57 mechanical working showed no difference from the control. The 35% RH always showed the lowest impact strength with the 80% RH showing the highest.

The lowest elongation was always produced by the alcohol modification with the next lower elongation being attributed to the 180°C modifications. The highest elongation was produced by the NaOH modification. Elongation was decreased by the mechanical working treatment. However, this difference was significant only with Deltapine Smooth Leaf, Stoneville 7A and Pima S-2. The various relative humidities for mechanical working only showed differences in elongation with Acala 4-42 and Stoneville 7A, where the 65% RH produced greater elongation.

The toughness values showed that, except for Lankart 57, the differences from the control came primarily in the 180°C and alcohol modifications where the values were reduced and in the NaOH modification where the value was much larger. The large values for the NaOH samples were a result of both an increased elongation and an increased tenacity. Even though the samples boiled in alcohol had an increased tenacity, the decrease in elongation was enough to cause it to have the low toughness value. In Lankart 57 the modifications at 72°C had some variation from the control. This was caused by the variations in elongation due to these modifications. The only variety which indicated a difference in toughness due to mechanical working was Pima S-2. This again reflects the difference in elongation due to mechanical working. The only varieties which had significantly different toughness values due to the various humidity treatments were Cal 7-8 and Lankart 57. This difference showed up only in the 35% RH treatment which was lower in toughness.

The 50% span length showed little difference among the atmospheric modifications. However, the 35% RH-180°C modification was lower than the control for Stoneville 7A. The alcohol modification was much lower and different from all other modifications. This was probably caused by the breaking of the fibers due to the apparent increased friction which caused them to hold more forcefully to each other and to the card teeth. The NaOH modification was lower than the control (an expected result of slack mercerization) but not as low as that treated in alcohol. Except in a few cases it was different from all other modifications for all varieties. Mechanical working reduced the 50% span length for all

varieties. The 50% span length was usually decreased as the treatment humidity decreased. The 35% RH treatment was lower for Cal 7-8 and Lankart 57. The 80% RH treatment was significantly higher than the 65% RH treatment for Deltapine Smooth Leaf. Three of the varieties showed change in 50% span length due to humidity.

The 2.5% span length showed much less variability among varieties due to modifications than did the 50% span length. No difference was seen between any of the atmospheric modifications for any of the varieties. The alcohol and NaOH modifications were always lower than the others with the NaOH modification being lower except for Pima S-2 and Stoneville 7A. These two modifications were significantly different from each other only with Cal 7-8. Mechanical working caused a significant drop in the 2.5% span length with all varieties. With few exceptions the reduction of the 2.5% span length with decreasing treatment humidity showed the same picture as that with the 50% span length with respect to treatment humidity.

The fineness values were affected by the atmospheric modifications only with Stoneville 7A where the control was different from the 65% RH-180°C modification. The fineness of the alcohol modification was significantly lower on all varieties except Pima S-2. The NaOH modification was significantly lower than all other modifications for all varieties. The mechanical working reduced the fineness in all varieties. This reduction may have been due to the fine, immature fibers being broken and lost in the card waste. The treatment humidities caused a significant difference only with Lankart 57 between the 65% and 80% RH treatments.

The immaturity values were affected very little by atmospheric modifications but were affected by both alcohol and NaOH modifications. The NaOH modification caused a much reduced value due to the swelling and was different from all other modifications. The alcohol modification caused reduced values; probably due to the change in surface properties which affects the Arealometer values, as explained in an earlier section of this report. A difference in immaturity value due to the mechanical working was seen only in Cal 7-8, Stoneville 7A and Lankart 57 where the mechanically worked tended to have a lower value. The immaturity value was significantly lower for the 35% RH treatment for Deltapine Smooth Leaf, Stoneville 7A and Pima S-2. For the Pima S-2 there was no difference in the 65% RH and 35% RH treatments.

The atmospheric modifications effect on alkali centrifuge value for the mechanically worked cottons was not different from the control except for Cal 7-8 and Deltapine Smooth Leaf where only the 180°C modifications were different. The samples boiled in alcohol were higher than the control except Acala 4-42. The evaluation of the ACV for the NaOH modification is meaningless since it involves another NaOH treatment. All varieties increased in ACV due to mechanical working. The 35% RH treatment caused a significantly higher ACV for Cal 7-8 and Deltapine Smooth Leaf. Also, for Lankart 57 the 35% RH was different from the 80% RH treatment.

Interactions from mechanical working effects.

The interactions of various treatments and modifications for the various physical properties are presented in the graphs of Figure C-1 through C-22. The effect of the modifications on the various parameters

for the six cottons are shown in Figures C-1 and C-2. This graphically presents information previously discussed and shows the comparative values for each cotton. The NaOH modification always stood out and the modification by boiling in alcohol was often very conspicious. The effects on the parameters due to modifications of decreasing humidity and increasing temperature are obvious, usually to the detriment of the fiber.

The effect of mechanically working each of the cottons for each modification on each parameter is shown in Figures C-3 through C-11. Except in a very few isolated cases the fibers which had been mechanically worked were higher in impact strength and tenacity, probably because the weak fibers were broken by the processing. There was very little difference in elongation or toughness due to mechanically working.

The 50% and 2.5% span lengths were both about equally affected by mechanically working at the various modifications for all cottons except Lankart 57 where there was only a very small difference due to modifications. The mechanically worked values were always less. Length uniformity followed the total length picture very closely.

The immaturity and fineness values were changed only very slightly by mechanically working. The greatest change was in Lankart 57.

The Alkali Centrifuge Value was greatly increased by the mechanically working. Lankart 57 and Acala 4-42 were least affected.

Figures C-12 through C-19 show the effect on the parameters of the mechanically worked samples for the three test humidities using data from all eight modifications. The 50% and 2.5% span lengths, stiffness, length uniformity and ACV were replotted in Figures C-20 through C-22 using only six of the modifications. The data from samples boiled in alcohol and treated with NaOH were omitted.

Length and length uniformity were affected less by being mechanically worked as humidity increased. Stiffness was affected little by mechanical working. Some indication of change was noted with Pima S-2 and Cal 7-8 where there was greater change due to mechanical working at the higher humidities. The fiber damage as indicated by ACV was nearly the same for all humidities. After being mechanically worked the ACV was usually higher at the lower humidities.

Correlations between physical properties.

The correlation coefficients between the physical properties for the varieties are in Tables C-III through C-IX of Appendix C. Comparison of Table A-III with Table C-IX shows that for all varieties combined and six modifications there was very little change in the correlation coefficients due to mechanically working the fiber. The correlation coefficients which include all varieties and all eight modifications did not match quite so well, especially the correlation of the various parameters with elongation.

When each variety was taken separately, varied correlations were found between the same parameters. As with the previous correlations discussed in Sections II and III of this report, the NaOH and alcohol samples usually controlled the correlation coefficient when it was involved. Therefore, most of this discussion will include only the correlation coefficients where the NaOH and alcohol samples were omitted.

It is especially interesting to compare the correlations for the mechanically worked samples to those for the samples which were crushed. For Cal 7-8 the correlation coefficients of the various variables

with impact strength were lower for mechanical working than for crushing except for those correlations with toughness and elongation. Tenacity correlations with elongation and the span lengths were near zero. All three of these were high with the crushed samples. The tenacity-toughness correlation was high as expected. Elongation was very highly correlated with toughness and to somewhat a lesser degree to 2.5% span length, fineness and impact strength. All the correlations with toughness were relatively low except for those with impact strength, tenacity and elongation. The next highest correlation with toughness was that with 2.5% span length. The 50% span length was strongly correlated negatively with ACV while the other correlations except with 2.5% span length were relatively low. The 2.5% span length was more strongly correlated to most of the other parameters than was the 50% span length; nevertheless, they were still relatively weak.

Deltapine Smooth Leaf correlations showed that impact strength was well correlated only with tenacity, the immaturity value and toughness. Tenacity was least correlated with elongation and ACV. The other correlation coefficients ranged from absolute values of 0.32 to 0.70. The correlation coefficients of tenacity versus the span lengths were negative. The correlations for impact strength versus the span lengths on Deltapine Smooth Leaf and for both impact and tenacity on all the other varieties were positive. Elongation for Deltapine Smooth Leaf was negatively correlated with ACV (-0.40) and highly correlated with toughness (0.86). The other correlations were reasonably low. All the toughness correlations were low except those with impact strength, tenacity and elongation. Both

the span lengths were strongly correlated negatively with ACV and positively with the fineness value. The fineness value was also well correlated negatively with ACV and tenacity.

Acala 4-42 data from mechanically worked samples showed that impact strength was well correlated with toughness, elongation and tenacity. A negative correlation (-0.33) of impact versus fineness was found. Acala 4-42, Stoneville 7A and, to a lesser degree, Lankart 57 were the only varieties where this correlation especially stands out. Tenacity was negatively correlated with fineness in the same way for all varieties except for Pima S-2. This correlation for Lankart 57 was a low one (-0.15). For Acala 4-42 elongation was well correlated with immaturity and toughness. The correlations of toughness with fineness and the span lengths were almost zero. The span lengths also had a low correlation with the immaturity value.

The correlations for Stoneville 7A were very similar to those of Acala 4-42. Two of the exceptions for Stoneville 7A were: (a) neither elongation nor toughness were well correlated with immaturity value, but 50% span length was; and (b) the elongation-50% span length correlation was near zero.

Pima S-2 showed correlations which were quite differenc from most of those of the other varieties. A weak negative correlation did exist between ACV and impact strength. The correlations of ACV with all the other physical properties were negative, except with immaturity value, and ranged from (-0.23) for impact strength to (-0.82) for 2.5% span length. The immaturity value had very low correlations with all the other

variables. The highest correlation was negative and was with fineness (-0.26). Most of the correlations of the fineness values with the other properties were also very low. Those worthy of note were with 50% span length (0.27), 2.5% span length (0.41), immaturity (-0.26) and ACV (-0.35). The 2.5% span length was weakly correlated to tenacity (0.28), elongation (0.24) and toughness (0.32). The two span lengths had very similar correlations. Toughness had significant correlations with all properties except fineness and immaturity. Elongation followed the same pattern except that there was low elongation-impact strength correlation.

Lankart 57 data showed that ACV is correlated negatively with all other parameters and only the correlations with 2.5% span length (-0.49) and fineness (-0.35) stood out. The immaturity value correlations were low except for those with 50% span length (0.36), 2.5% span length (0.66) and fineness (0.68). Fineness had a correlation coefficient (absolute value) below 0.20 except with 2.5% span length (0.63) and ACV (-0.35). Both the span lengths were correlated positively with impact strength. Their correlations with tenacity were positive but much lower. Toughness had a low correlation with all parameters except tenacity (0.46) and elongation (0.88).

SECTION V

EFFECTS OF SOME HARSH TREATMENTS ON FIBER SPINNABILITY

The final evaluation of the value of a fiber is determined to a great extent by the way it moves through the mill process. This especially applies to the way it spins and the quality of yarn obtained.

The effect of fiber characteristics on spinnability and yarn properties have been studied by many investigators. Some of the more recent have been the studies of Grant et al. (6,7), Louis and Fiori (19), Fiori and Grant (5) and Weiss et al. (28). These studies considered the influences of initial fiber properties along with the induced changes due to heating, moisture, machining and mechanical handling of the fiber on the spinning behavior and yarn properties.

The Spinning Test

This investigation used 12 samples from the variety-modification combinations discussed earlier in this report. The 12 samples were selected for their wide range in fiber characteristics. These samples and the parameters tested are listed in Table III, page 4. The yarn was spun by the procedures outlined for the small scale spinning test by Landstreet et al. (18).

Fiber and Yarn Tests

The fiber properties tested, except for fiber torsion and twisting and roping, were made on samples taken (a) before any processing, (b) after

second drawing, and (c) at the spinning frame after having been drawn ready for spinning into yarn but before twisting. Fiber torsion was measured on individual fibers in the device shown in Figure 8 and Figure F-6. Fiber twisting and roping was determined by two methods which are discussed in a later part of this report.

Five yarn parameters were determined as shown in Table III, page 4. Yarn strength and elongation were determined from the single end Uster tester. Yarn grade or appearance was determined according to the procedures of ASTM designation D 2255-64 and yarn abrasion according to the procedures of ASTM Designation D 1379-64. The yarn abrasion tests were made at the Southern Utilization Research and Development Division, ARS, USDA. Yarn linear density compared the weights of short lengths of yarn. Yarn from a bobbin was wound (100 turns) on a cylindrical bar with a circumference of 2.63 in. The yarn was cut along one side to give 100 pieces of yarn 2.63 in. long. Ten pieces were randomly selected and weighed individually. Two such sub-samples were taken for each variety-modification combination and replication.

Fiber twisting and roping and the fiber torsional stiffness of the 12 cottons which were spun will first be discussed and then the fiber properties at the various stages of processing. The yarn properties will be discussed last.

Torsional Stiffness

Torsional analysis.

The torsional stiffness was obtained by suspending a short length of fiber from one end of a needle. The other end was attached to a second

Figure 8. Apparatus for measuring fiber torsion.

needle onto which a bob of known moment of inertia could be attached. The length of the fiber, L, the moment of inertia, I, of the suspended bob and needle, and the period of torsional oscillation, P, of the bob due to the stiffness of the fiber are related to each other by the relationship for torsional rigidity, Γ, for the fiber,

$$\Gamma = 8\pi^3 \frac{IL}{P^2} .$$

In this relationship, the torsional rigidity of a fiber measures the resistance to twisting and is defined as the couple required to twist the fiber one complete turn per centimeter length of fiber. The units used are cgs. The general procedure was that followed by Meredith (21).

Torsional measurement procedure.

The particulars of this experimental determination of single fiber stiffness as differing from Meredith's procedure were as follows. Rather than determine Γ itself, only L/P^2 was determined. This is directly proportional to the torsional rigidity when the moment of inertia of the oscillating bob is held constant. This value of L/P^2 was measured on at least twenty fibers taken from each of the bulk samples.

After a short length of each fiber to be tested had been attached between two needles with epoxy resin and the epoxy had cured, the fiber and one of the needles was suspended from the other needle. The length of the fiber, L, was measured and recorded along with vibroscope measurements of linear density (to be discussed later). A small weight, approximately equal to the weight of the pendulum bob, was attached to the free end and was left suspended overnight to prevent a drift of the zero position

of the pendulum bob during the measurement. The next day the small weight was removed and the needles were demagnetized by moving them slowly into and out of an oscillating (60 Hz) magnetic field. The needle onto which the top of the fiber was attached was then mounted onto a system which included a small leaf spring. The spring absorbed shocks on the fiber which would normally break the fiber. A pendulum bob of known weight (0.5930 g) was placed on the suspended needle and the system was hung in a chamber (Figure 8, page 60) which was controlled at 72^{o}F and 65% RH with magnesium acetate crystals in contact with a saturated aqueous solution of the same salt. The torsional periods of oscillation were measured in this chamber which consisted of a clear, hollow cylinder with a flat plastic window to remove optical distortions. The ends of the cylinder were covered with aluminum plates but were machined so that the suspended fiber on its mount could be introduced through the top plate. The bottom plate had a hole in the center through which a small cylindrical rod could be introduced and brought into contact with the suspended bob for the purpose of setting the bob into oscillation. Oscillation was started by giving the pendulum bob an initial twist of 180 degrees. The time of two complete oscillations within one twist of the bob was measured using a stopwatch. This measurement was repeated a second time and the data averaged to determine the period, P, of one oscillation. The torsional stiffness value, L/P^2, for the particular fiber was then calculated.

Within one sample, the torsional stiffness of single fibers as determined by L/P^2 was found to vary greatly. However, L/P^2 was found to be reasonably highly correlated with the fiber linear density

and, therefore, a log log graph of L/P^2 versus fiber linear density in tex was plotted for each of the samples. In order to compare the results of one cotton or treatment with another, a normalization to a similar base was necessary. This was accomplished by drawing a best fit line through the points representing each sample of twenty fibers. After a number of observations it was decided to take from each graph the value of L/P^2 corresponding to a linear density of 0.17 tex. This is the value given in Table VII for each of the three cottons with their four treatments.

Fiber linear density.

The general technique for obtaining the linear density of the fiber by using the vibroscope method has been outlined in ASTM Designation D 1577-66. This experiment utilized an adaptation of the method. The sampling and testing methods were as follows. A small bundle of fibers taken from the bulk sample was placed on a black velvet board and from this 25 fibers were chosen at random. The center portions of these 25 fibers were mounted as discussed in the preceding paragraphs. The fiber was suspended between two electrodes to which a variable alternating voltage was applied. The alternating field interacted with the fiber and, depending on the tension applied to the fiber at the suspended end, caused the fiber to resonate or vibrate in its fundamental mode at a certain frequency, equal to the frequency of the electric field. In addition to the tension, T, applied to the fiber, the resonant frequency is dependent, also, on the linear density, δ, and the length, L, of the fiber according to the relationship

$$\delta = \frac{T \times 980 \times 10^5}{4L^2 F^2} .$$

TABLE VII. Torsional Stiffness of Three Cotton Varieties with Four Modifications

Modification	Variety: Cal 7-8	Variety: Deltapine Smooth Leaf	Variety: Pima S-2	Modification Mean (*)
Control	2.79	2.60	2.50	2.63
65%-180^{o}C	2.98	2.04	3.46	2.83
Alcohol	3.32	2.62	3.40	3.11
NaOH	3.04	3.44	3.61	3.36
Variety Mean (*)	3.03	2.68	3.24	

(*) These means were checked by the analysis of variance and found to be different at the 5% level of significance.

The units of linear density are tex when T is in grams, L is in centimeters and F is in cycles per second. The tension, T, is the weight of the lower suspended needle.

The main apparatus used consisted of a basic 2 in. x 2 in. slide projector into which the electrodes or deflection plates were incorporated. When the fiber was placed between the deflection plates, an image of the electrodes and fibers was projected to a nearby screen onto which was attached a scale. The length of the fiber image is related geometrically to the actual length of the fiber object. From this simple relationship, the fiber length, L, was determined. A variable alternating voltage was produced by an electronic sine wave generator, the output of which was connected to the deflective plates and the amplitude increased sufficiently to give a clear image on the projection screen of the fiber "bloom" at resonance.

Torsional results.

The values of L/P^2 at 0.17 tex are shown in Table VII. An analysis of variance indicated that there was a significant difference at the 5% level among the variety means and among the modification means.

The values of L/P^2 varied in a different way from one variety to another for each modification (see Table VII). However, the variety modification interactions were not significant. Nevertheless, it is interesting to note the within variety and within modification variations. Except for the control, Pima S-2 was always higher than the other varieties. Pima S-2 had the low value for the control. Cal 7-8 was high for the control, and low for the NaOH treatment. Also, the alcohol treated Cal 7-8

The units of linear density are tex when T is in grams, L is in centimeters and F is in cycles per second. The tension, T, is the weight of the lower suspended needle.

The main apparatus used consisted of a basic 2 in. x 2 in. slide projector into which the electrodes or deflection plates were incorporated. When the fiber was placed between the deflection plates, an image of the electrodes and fibers was projected to a nearby screen onto which was attached a scale. The length of the fiber image is related geometrically to the actual length of the fiber object. From this simple relationship, the fiber length, L, was determined. A variable alternating voltage was produced by an electronic sine wave generator, the output of which was connected to the deflective plates and the amplitude increased sufficiently to give a clear image on the projection screen of the fiber "bloom" at resonance.

Torsional results.

The values of L/F^2 at 0.17 tex are shown in Table VII. An analysis of variance indicated that there was a significant difference at the 1% level among the variety means and among the modification means.

The values of L/F^2 varied in a different way from one variety to another for each modification (see Table VII). However, the variety modification interactions were not significant. Nevertheless, it is interesting to note the within variety and within modification variations. Except for the control, Pima S-2 was always higher than the other varieties. Pima S-2 had the low value for the control. Cal 7-8 was high for the control, and low for the NaOH treatment. Also, the alcohol treated Cal 7-8

value was almost as high as that for Pima S-2. Deltapine Smooth Leaf had the low value for the 65% RH-180°C and the alcohol treated samples. The variety means showed Cal 7-8 low and Pima S-2 high.

Among the modifications (within varieties), the control sample had the low value except for Deltapine Smooth Leaf, for which the 65% RH-180°C treatment was low with the control sample falling next in line. The NaOH treated had the highest value on Deltapine Smooth Leaf and Pima S-2. The modification means showed the following order from low to high: control, 65% RH-180°C, alcohol, NaOH.

Twisting and Roping

Twisting and roping for the purpose of this investigation is considered to be a measure of the inter-fiber entanglement that accompanies groups of neighboring fibers when processed or moved relative to each other. Experimental procedures and techniques were developed in terms of this definition.

Twisting and roping procedure.

In order to produce a sample showing twisting and roping, a parallel array of fibers was prepared by hand combing a sample of cotton using a pair of Fibrograph combs. Combing was continued until the cotton was equally distributed on the two combs. At this point, two methods were experimentally tested for obtaining a measure of twisting and roping.

The first method (in Table VIII(a)) consisted of removing a small portion of the beard from one of the combs using a spring loaded clip. The specimen was prepared as a sample would be prepared for a

strength test using standard Pressley clamps. However, only one of the two Pressley clamps was used. The cotton on the back side of the clamp was trimmed off and there remained a beard extending from one side only. The beard remaining was subjected to the suction of a vacuum and the flutter of the fibers due to the turbulent flow of air into the vacuum system resulted in the fibers of the beard becoming entangled and twisted with each other. This entanglement of fibers was the experimentally produced twisting and roping. A quantitative measure of this inter-fiber twisting was made by hanging the sample and clamp on a Hunter 100 lb balance. The teeth of a standard Fibrograph hand comb were placed in the mass of fibers close to the jaws of the Pressley clamp and the comb slowly pulled down. The amount of force necessary to draw the comb through the mass of fibers was measured and recorded. Essentially no fibers were removed from the specimen in this process. The process of entanglement and consequent force measurement was performed three times on each specimen. The values of Table VIII(a) are the averages of the three determinations after being normalized as described below. This was also similarly repeated for a number of different specimens obtained from a standard cotton. In order to normalize the values obtained, both between different specimens of the same sample and values obtained from specimens of other treatments or varieties, the force necessary to comb out the roping was divided by the weight of the specimen. Therefore, the quantitative value obtained on each test was the force (lbs) required to comb out the effect of roping per unit mass (mg). The complete unit is, therefore, in lbs force per unit mg mass of sample. These data, obtained on the three cottons and four treatments are given in Table VIII(a).

TABLE VIII. Twisting and Roping on Three Cotton Varieties with Four Modifications

Modification	Variety			Modification Mean
	Cal 7-8	Deltapine Smooth Leaf	Pima S-2	
	(a) Method 1 (lb/mg)			
Control	0.195	0.230	0.355	(*) 0.260
65%-180^{o}C	0.195	0.225	0.255	0.225
Alcohol	0.190	0.270	0.355	0.272
NaOH	0.150	0.130	0.180	0.153
Variety Mean (**)	0.182	0.214	0.286	
	(b) Method 2 (%)			
Control	12.4	11.6	15.0	(**) 13.0
65%-180^{o}C	11.4	11.4	14.4	12.4
Alcohol	9.0	4.2	4.8	6.0
NaOH	2.8	2.2	3.4	2.8
Variety Mean	8.9	7.3	9.4	

(*) (**) These means were checked by the analysis of variance and found to be different at the 5% and 1% level of significance, respectively.

The second method (Table VIII(b)) consisted of taking a sample of cotton and combing the sample with two standard Fibrograph combs until the sample was evenly distributed between the two combs. One comb was used as the test specimen. The cotton beard of the second comb was removed, weighed to 0.01 mg and the weight subtracted from the initial known weight of cotton. This resultant weight was the weight of the test beard. The test beard, still on the comb, was subjected to turbulent air flow by placing the beard into a slit through which air was drawn. This turbulent air flow resulted in twisting and roping of the fibers in the test beard. When the beard was combed with a second clean comb, some of the fibers were removed. The amount removed would be expected to depend on the degree of roping. This amount removed was normalized to the amount present in the test beard before combing and related to roping in units of mg removed per 100 mg of test sample. This is also the percent of fibers removed upon combing the roped sample and is recorded as such in Table VIII(b).

Twisting and roping results.

Analysis of variance of the twisting and roping data showed that with Method 1 there was a difference between variety means at the 1% level of significance. However, there was no significant difference found between variety means for Method 2.

As with torsion, the twisting and roping data showed no variety modification interaction. The difference in the variety and modification means are discussed with this in mind. Among varieties for Method 1, Cal 7-8 had the least value except for the NaOH treatment for which

Deltapine Smooth Leaf had the lowest value. Pima S-2 had the highest value as would be expected with the longer relatively fine fiber. Method 2 produced similar results to Method 1 for the control, 65% RH-180°C and NaOH modifications. However, for the alcohol modification for Method 2 the value for Cal 7-8 was about twice as high as those for the other two varieties. This evidently reflects on the resultant condition of the fiber surface due to the modification. The surface condition of Cal 7-8 caused the fibers to be pulled from the combs in Method 2 where as they were held more securely in Method 1. The NaOH modification had reduced values for both Methods 1 and 2. This was probably due to increased stiffness resulting from the increased cross section and decreased length. The inconsistency from one modification to another caused the variety means to not be significantly different for Method 2. However, examination of Table VIII(b) shows that the between variety differences were large for some of the modifications.

For Method 1 the modification means were different at the 5% level and for Method 2 they were different at the 1% level. For Method 1 the highest modification mean was with alcohol and decreased in order with the control, 65% RH-180°C and NaOH. Method 2 means fall in the same order except that alcohol changed from first to third place. The Method 1 within variety (among modification) values for Deltapine Smooth Leaf and Pima S-2 fall in the same order as the modification means. For Cal 7-8 there is only a very small difference between the control, 65% RH-180°C and alcohol modifications. For Method 2 each within variety variation follows the same pattern as the modification means except for Cal 7-8 where, again, the high value for the alcohol modification distorts the picture.

Fiber Properties at Several Stages of Processing

The effect on some fiber properties were tested before processing, at second drawing and at spinning as indicated in Table III, page 4. The means are shown in Tables E-I through E-VII of Appendix E. A graphical presentation is given in Figure E-1 through E-4. The Duncan's multiple range comparison has been made on each property tested (tenacity, elongation, toughness, 50% and 2.5% span length, length uniformity and ACV) (a) within modifications among varieties and stages of processing, (b) within varieties among modifications and stages of processing, and (c) within stages of processing among modifications and varieties.

Tenacity data are presented in Table E-1. There were differences among varieties within both modifications and processing levels. Also differences were indicated among modifications within varieties and within processing levels. These differences were expected since the varieties and modifications were picked because of their differences. Neither of the three processes changed the relative order of the tenacity values due to the modifications from the control. There was no difference across process levels within modifications except for the samples boiled in alcohol. A reduction in strength was seen from unprocessed to second drawing. The only difference across process stages within varieties was in the Pima S-2 where, again, there was a decrease at second drawing and an increase (not significant) at spinning.

Differences were shown in elongation (Table E-II) among varieties within modifications and within levels of processing, as well as among modifications within varieties and within stages of processing. Again,

these among variety and among modification differences were expected. Differences among processing levels within modifications were not evident with the control and alcohol modifications. The 65% RH-180°C modified samples showed an increase in the elongation as processing progressed. The NaOH modified samples showed an elongation increase from unprocessed to second drawing and then a decrease again at spinning. Differences in elongation among process levels within varieties only existed in Deltapine Smooth Leaf where there was an increase in elongation from unprocessed to second drawing.

The effect of processing on fiber toughness (Table E-III) showed the expected differences for the variety modification combinations. For Deltapine Smooth Leaf the strength was below Cal 7-8 for all modifications and all process levels. Yet, the elongation was up sufficiently over Cal 7-8 to make the toughness not different within processing levels and significantly higher for all modifications except NaOH where it was significantly different on the low side. This might indicate that there is a limit to which the NaOH modification can increase the elongation, regardless of the initial elongation of the untreated fiber. Modifications within processing levels were all affected in a similar manner as well as varieties within processing levels. Processing levels within modifications were not different. Processing levels within varieties showed that Cal 7-8 was not affected; however, Deltapine Smooth Leaf showed a toughness increase from unprocessed to second drawing. Pima S-2 showed a decrease from no processing to second drawing with no change from second drawing to spinning.

The way in which length (Table E-IV and E-V) varied within modifications among varieties was very similar to the variation in the control samples. The variations of length within varieties among modifications were all similar. On the 2.5% span length the alcohol modification was higher than NaOH on all except Deltapine Smooth Leaf, but on the 50% span length the NaOH samples were higher than the alcohol. A similar trend seems to apply to the length values within process levels among modifications. The length values within modification among processing levels showed no difference except for alcohol modification for 2.5% span length. The values decreased significantly with each process level. There was no difference within varieties among process levels for 50% span length but for 2.5% span length there was a significant drop from no processing to the second drawing with Deltapine Smooth Leaf and a drop from second drawing to spinning with Pima S-2.

The control and NaOH modification produced the highest length uniformity and alcohol the lowest on all varieties (Table E-VI). Alcohol was the only modification which showed any change due to processing, where there was an increase from unprocessed to second drawing. This was due to excessive breakage as indicated by the decrease in 2.5% span length with processing and no change in the 50% span length.

The ACV (Table E-VII) showed a significant increase from no processing to second drawing within varieties and within modifications except for 65% RH-180°C modification. However, there was no significant difference for the ACV between second drawing and spinning on the modified samples.

Table IX presents one additional way of examining the fiber damage due to processing. The average percent change is given for 2.5% span length and ACV. This may be compared with Table E-V and Table E-VII which gives the means and the Duncan's range comparison. Even though Table IX shows that the control has a larger ACV increase than the other modifications except alcohol, Table E-VII shows that each of the unprocessed modifications except NaOH have an increased ACV as compared to the control. As a result, the ACV at both second drawing and spinning are higher for the 65%-180°C modification than for the control.

Yarn Characteristics

Each of the 12 cottons processed were spun into 22's cc (27 tex) yarn and the yarn evaluated by the tests shown in Table III, page 4. The data are presented in Tables X through XII and graphically in Figures E-5 through E-8 in Appendix E.

The single end yarn strength as determined by the Uster single end tester was found to be significant both among modification means (5% level) and among variety means (1% level). Each modification for each variety gave a lower yarn strength than the control. The NaOH modification gave the lowest yarn strength for each variety even though it was very high in both fiber strength and elongation. The second lowest yarn strength was produced by the 65% RH-180°C modification with the alcohol modification being next in strength to the control. This last fact should be examined in light of the rough surface (high coefficient of friction) with respect to NaOH samples. This high strength from alcohol

TABLE IX. Percent Change in 2.5% Span Length and ACV
Due to Processing Within Varieties
and Within Modifications

	No Processing to Second Drawing		No Processing to Spinning	
	2.5% SL	ACV	2.5% SL	ACV
Modifications				
Control	0.1	4.2	0.3	6.7
65% RH-180°C	-0.1	1.4	0.1	3.2
Alcohol	-2.4	9.3	-5.4	8.0
22% NaOH	1.7	2.4	0.8	3.4
Varieties				
Cal 7-8	0.8	4.3	1.1	4.9
Deltapine Smooth Leaf	-1.5	4.0	-2.8	4.9
Pima S-2	0.2	4.7	-1.4	6.2

Note: A positive number indicates an increase in the parameter due to processing and a negative number indicates a decrease in the parameter due to processing.

TABLE X. Yarn Strength and Strength Variability of Three Cotton Varieties with Four Modifications

Modification	Variety: Cal 7-8	Variety: Deltapine Smooth Leaf	Variety: Pima S-2	Modification Mean
	(a) Single End Yarn Strength (grams)			
Control	512	426	620	(*) 520
65%-180^{o}C	456	390	555	467
Alcohol	504	377	560	480
NaOH	440	336	500	425
Variety Mean (**)	478	382	559	
	(b) Yarn Strength Variability (% CV)			
Control	10.4	10.7	9.1	(**) 10.0
65%-180^{o}C	10.6	11.0	9.4	10.4
Alcohol	16.6	23.6	19.8	20.0
NaOH	13.6	15.4	10.9	13.3
Variety Mean (**)	12.8	15.2	12.3	

(*) (**) These means were checked by the analysis of variance and found to be different at the 5% and 1% level of significance, respectively.

TABLE XI. Yarn Elongation and Yarn Grade of Three Cotton Varieties with Four Modifications

Modification	Variety			Modification Mean
	Cal 7-8	Deltapine Smooth Leaf	Pima S-2	
	(a) Yarn Elongation (%)			(**)
Control	6.3	7.3	7.3	7.0
65%-180°C	5.8	6.9	6.6	6.4
Alcohol	5.3	5.5	6.0	5.6
NaOH	9.9	9.6	10.8	10.1
Variety Mean (**)	6.8	7.3	7.7	
	(b) Yarn Appearance Grade (Index)			(**)
Control	127	120	129	125
65%-180°C	127	120	129	125
Alcohol	94	70	83	82
NaOH	125	118	126	123
Variety Mean (**)	118	107	117	

(**) These means were checked and found to be significant at the 1% level.

TABLE XII. Yarn Abrasion and Yarn Linear Density of Three Cotton Varieties with Four Modifications

Modification	Variety: Cal 7-8	Deltapine Smooth Leaf	Pima S-2	Modification Mean
	(a) Yarn Abrasion (cycles)			
Control	3202	2730	4546	(**) 3493
65%-180°C	1722	1834	2366	1974
Alcohol	389	392	600	460
NaOH	1114	832	3350	1765
Variety mean (**)	1606	1447	2716	
	(b) Linear Density (% CV)[1]			
Control	10.2	9.7	11.6	10.5
65%-180°C	10.1	14.7	8.1	11.0
Alcohol	17.0	29.1	16.6	20.9
NaOH	18.9	14.5	10.0	14.4
Variety mean	14.1	17.0	11.6	

(**) These means were checked and found to be significant at the 1% level.

[1]These means were not checked by the analysis of variance. Each value except the means is based on 40 individual readings.

treated cottons was in spite of the fact that with only 10 spindles one operator was kept busy correcting ends down.

The yarn strength variability was highly significant (as noted in Table X(b)) both among varieties and modifications. The coefficient of variation was highest for all varieties with the alcohol modification with the NaOH samples next highest. Variations within the control and the 65% RH-180°C modification were both small. Cal 7-8 and Pima S-2 had approximately the same yarn strength coefficient of variation and Deltapine Smooth Leaf had the highest value.

Yarn elongation means, both for modification and for varieties, were significantly different at the 1% level. Each modification was lower in elongation than the control except NaOH samples where the elongation was 2.6 to 3.7 percentage units higher than the control. This means that only a part of the increased fiber elongation was transferred to the yarn. The alcohol modification had the lowest yarn elongation.

Yarn grade was determined by the method specified in ASTM Designation 2255-64 and assigned numbers as specified. The means were analyzed and found to vary significantly at the 1% level among modifications and among varieties. The alcohol modification produced the lowest grade with a very obvious neppy, nonuniform and rough condition. The grade for the other samples was very uniform, both among modifications and among varieties. Deltapine Smooth Leaf had the lowest grade. The average grade for Pima S-2 and Cal 7-8 was the same.

Yarn abrasion tests showed that all varieties and modifications were significantly different at the 1% level. The values in Table XII(a) are the number of abrasion cycles to the definite end point. The control

samples had the highest cycles to rupture and the alcohol modification had the lowest value. The NaOH samples were also low but not as low as the alcohol samples for Cal 7-8 and for Deltapine Smooth Leaf. The Pima S-2, NaOH sample held up better under the abrasion tests. It was second only to control. The 65% RH-180°C modification provided an abrasion value approximately one-half that of the control on all varieties except Deltapine Smooth Leaf. This modification was relatively higher for Deltapine Smooth Leaf; however, the control sample for this variety did have the lowest value for the three varieties.

Table XII(b) shows the coefficient of variation of 40 determinations of the linear density of short lengths of yarn as previously described. The large differences among varieties and among modifications were expected. As with yarn strength, the largest variability was with the alcohol modification and with Deltapine Smooth Leaf. The total picture of yarn linear density followed the same pattern, throughout, as the yarn strength variability. The variation of the modified cottons of Pima S-2, except for alcohol, was especially low. Both 65%-180°C and NaOH were lower than the control on the Pima S-2.

SECTION VI

EFFECTS OF ATMOSPHERIC CHANGES ON INTERFIBER ACTION

Earlier parts of this report have discussed the problem of obtaining an adequate measurement of friction for the evaluation of the surface character of the fiber. Other work in the laboratory led to observations of the interfiber cooperation in bundles of fibers in a dynamic condition. A method of test resulted which measured the "shear friction" of a mass of fibers in an oscillating system (11,12). The background justification for the test along with the theoretical considerations have been provided in these references. Application of this test method to the cottons and modification of this investigation was made.

Heat Effects

The samples were prepared by blending, carding, collection in lap form and heat treating between the grooved metal plates as previously described. After the heat treatment, each sample was recarded and "shear friction" measurements were made.

Initially, only controls, 140°C and 180°C treated samples were tested. All cottons decreased in "shear friction" from control to 140° and increased from 140° to 180°C. One cotton, Acala 4-42, was tested at several intermediate temperatures and the results are shown in Figure 9. Later a second set of controls and 100°C treated samples were prepared and tested on each cotton.

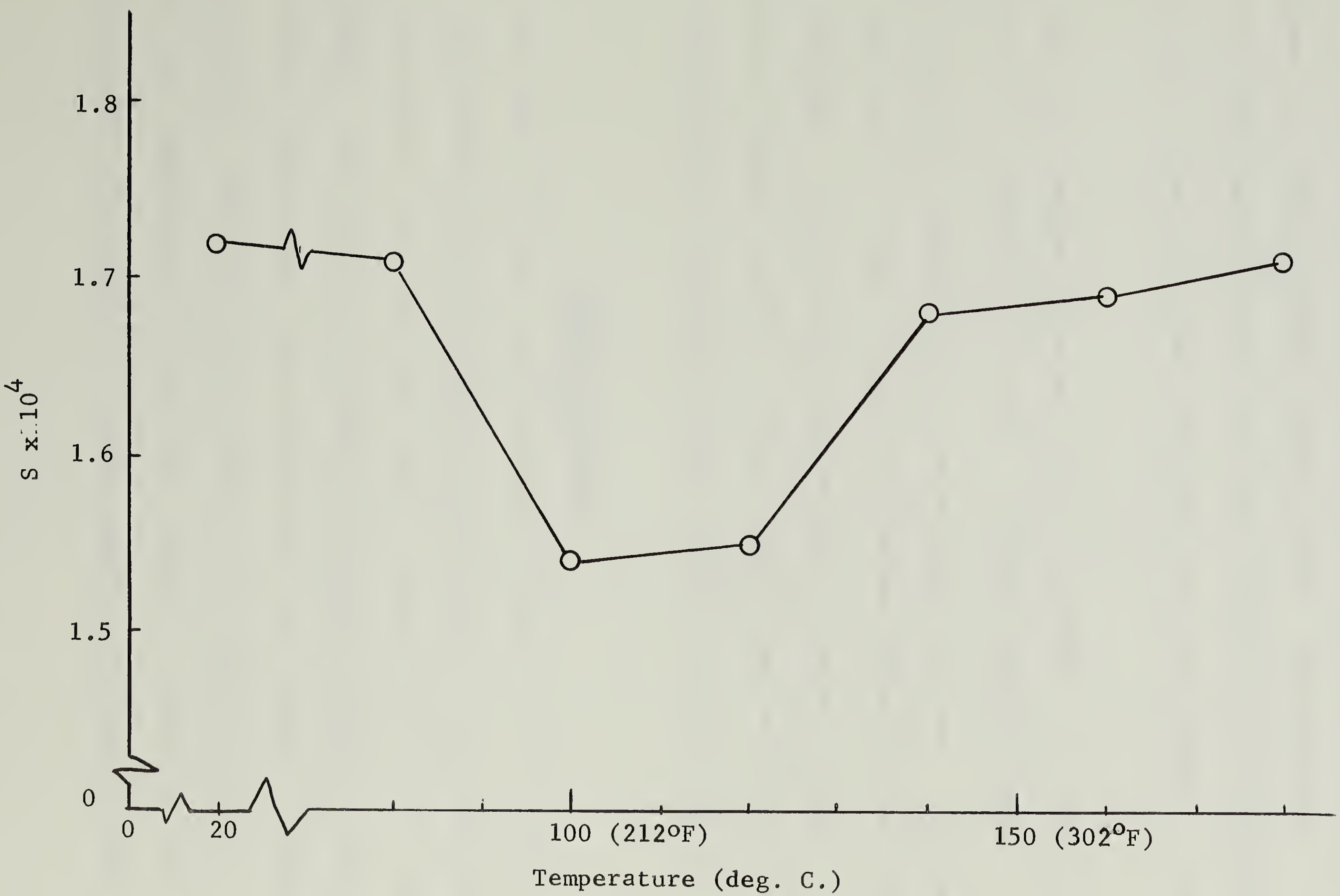


Figure 9. The effect of heat treatment on "shear friction" for Acala 4-42.

A plot of the "shear friction" versus the treatment temperature is given in Figure 10 for each cotton at the carding relative humidity. This plot shows the same pattern for all cottons. Pima S-2 and Cal 7-8 have the lower values with Deltapine Smooth Leaf, Acala 4-42 and Stoneville 7A placed in a close grouping slightly above. The values for Lankart 57 are widely separated from the other cottons. It is interesting to note that Cal 7-8 has the lowest Arealometer value and Lankart 57 the highest.

There was a marked decrease from 20°C to 100°C. No change in "shear friction" was observed up to 80°C. A sudden change occurred between 80°C and 100°C probably due to the melting of the wax. Cottons that had been treated at higher temperatures became yellow and the "shear friction" increased. It may be that the melting of the wax allowed it to spread and form a smoother surface. Higher temperatures may have caused the wax to disintegrate - producing a higher "shear friction" surface.

Humidity Effects

The "shear friction" was determined initially at the carding humidity. Each sample was then brought to equilibrium at the humidities shown in Table XIII in the order given and the "shear friction" determined at each humidity. One phase of the humidity cycling is shown in Figure 11. for the control. All cottons, even though there were varietal differences, behaved similarily. There was little change in the "shear friction" between the test humidities of 30% and 55%, however, a rapid rise occurred between 65% and 80%. The result of further humidity cycling, as shown

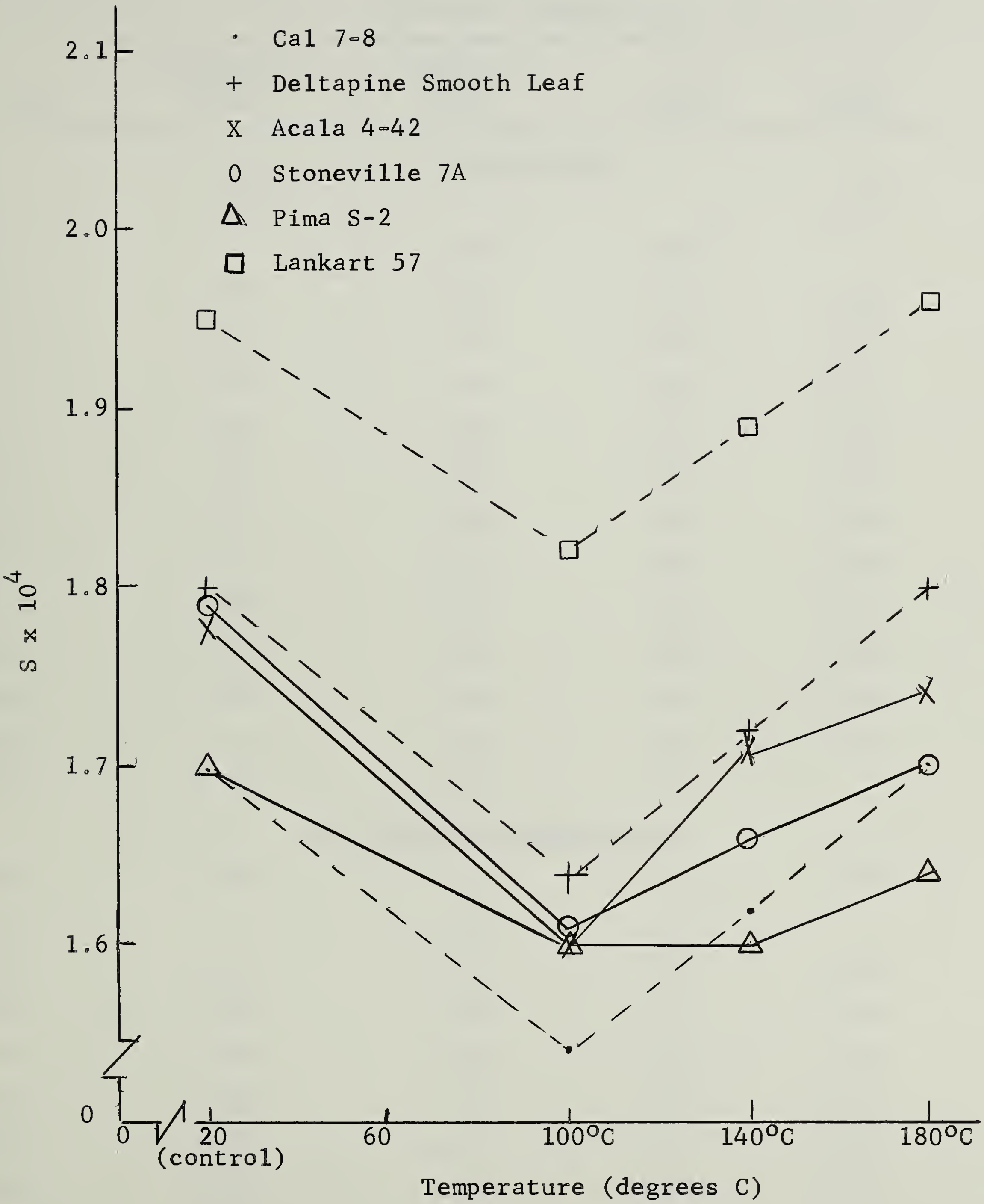


Figure 10. Effect of heat treatment on "shear friction" at the carding relative humidity.

TABLE XIII. Results of Cycling Relative Humidity on "Shear Friction" ($Sx10^4$) for Six Cottons Treated at Various Temperatures.[1]

% RH	Control 1 22°C	Control 2 22°C	100°C	140°C	180°C
			Treatment Temperature		
		(a) Cal 7-8			
50	1.70[2]			1.62[2]	1.70[2]
55		1.72[3]	1.54[3]		
65	1.97	1.88	1.77	1.82	1.86
30	1.77	1.74	1.63	1.71	1.74
45	1.78	1.75	1.62	1.67	1.73
55	1.84	1.80	1.67	1.73	1.78
80	3.28	3.26	3.23	3.06	2.96
65	2.17	2.19	2.05	2.09	2.07
55	2.11	2.11	2.01	2.05	2.06
45	2.09	2.14	1.94	1.97	1.97
30	2.07	2.08	1.90	1.98	2.00
80	2.69	2.68	2.52	2.55	2.54
30	2.11	2.02	1.90	2.01	2.02
80	2.88	2.92	2.78		
		(b) Deltapine Smooth Leaf			
50	1.80[2]			1.72[2]	1.80[2]
55		1.74[3]	1.64[3]		
65	2.17	1.97	1.82	2.00	2.18
30	1.90	1.88	1.76	1.80	1.86
45	1.94	1.81	1.74	1.82	1.93
55	2.08	1.91	1.81	1.83	1.92
80	3.49	3.65	3.16	3.32	3.28
65	2.35	2.25	2.09	2.21	2.26
55	2.26	2.26	2.08	2.12	2.18
45	2.20	2.14	1.99	2.09	2.14
30	2.20	2.17	2.02	2.07	2.12
80	2.77	2.71	2.64	2.59	2.60
30	2.20	2.19	2.03	2.05	2.09
80	2.88	3.04	2.84		

TABLE XIII. Results of Cycling Relative Humidity on "Shear Friction" ($S \times 10^4$) for Six Cottons Treated at Various Temperatures.[1]

% RH	Control 1 22°C	Control 2 22°C	100°C	140°C	180°C
		Treatment Temperature			
		(c) Acala 4-42			
50	1.78[2]			1.71[2]	1.74[2]
55		1.71[3]	1.60[3]		
65	2.05	2.02	1.74	1.90	1.95
30	1.86	1.83	1.67	1.74	1.78
45	1.84	1.84	1.65	1.74	1.80
55	1.92	1.88	1.71	1.80	1.87
80	3.65	3.39	3.50	3.18	3.18
65	2.33	2.27	2.07	2.21	2.20
55	2.28	2.20	2.08	2.09	2.12
45	2.23	2.16	2.00	2.10	2.11
30	2.20	2.20	2.06	2.13	2.14
80	2.84	2.75	2.59	2.66	2.62
30	2.25	2.24	2.06	2.13	2.14
80	3.10	3.04	2.84		
		(d) Stoneville 7A			
50	1.79[2]			1.66[2]	1.70[2]
55		1.69[3]	1.61[3]		
65	2.09	1.92	1.78	1.89	1.96
30	1.87	1.79	1.72	1.74	1.74
45	1.87	1.79	1.69	1.73	1.74
55	1.97	1.86	1.74	1.76	1.76
80	3.46	3.43	3.12	3.15	2.96
65	2.21	2.18	2.05	2.06	2.02
55	2.12	2.10	2.02	1.98	1.96
45	2.14	2.02	1.97	2.02	1.99
30	2.14	2.09	1.98	2.05	1.98
80	2.74	2.68	2.54		
30	2.09	2.06	1.98	1.98	1.94
80	2.84	2.95	2.82		

TABLE XIII. Results of Cycling Relative Humidity on "Shear Friction" ($Sx10^4$) for Six Cottons Treated at Various Temperatures.[1]

	Treatment Temperature				
% RH	Control 1 22°C	Control 2 22°C	100°C	140°C	180°C
		(e) Pima S-2			
50	1.70[2]			1.60[2]	1.64[2]
55		1.65[3]	1.60[3]		
65	1.82	1.72	1.62	1.71	1.76
30	1.72	1.74	1.63	1.68	1.66
45	1.74	1.70	1.59	1.67	1.65
55	1.76	1.73	1.60	1.66	1.69
80	2.92	2.87	2.62	2.71	2.72
65	2.09	1.98	1.86	1.99	1.99
55	2.02	1.96	1.84	1.93	1.94
45	2.04	1.96	1.87	1.97	1.96
30	2.11	2.02	1.92	2.02	2.01
80	2.43	2.34	2.18	2.34	2.34
30	2.09	2.11	1.95	2.00	2.02
80	2.65	2.59	2.46		
		(f) Lankart 57			
50	1.95[2]			1.89[2]	1.96[2]
55		1.91[3]	1.82[3]		
65	2.62	2.31	2.08	2.36	2.35
30	2.11	2.04	1.94	2.06	2.04
45	2.10	2.03	1.94	2.04	2.03
55	2.22	2.09	1.98	2.07	2.08
80	3.72	3.82	3.47	3.53	3.29
65	2.36	2.40	2.29	2.28	2.26
55	2.30	2.36	2.20	2.28	2.22
45	2.29	2.29	2.15	2.22	2.17
30	2.31	2.38	2.20	2.30	2.26
80	2.97	2.96	2.78	2.80	2.74
30	2.31	2.30	2.16	2.27	2.21
80	3.11	3.27	3.06		

[1] Each entry is the average of four specimens and each column provides data from the same four specimens as they were tested at the various humidities in order starting at the top of the column.

[2] The four specimens from which all data were taken for these columns were carded at 50% RH.

[3] The four specimens from which all data were taken for these columns were carded at 55% RH.

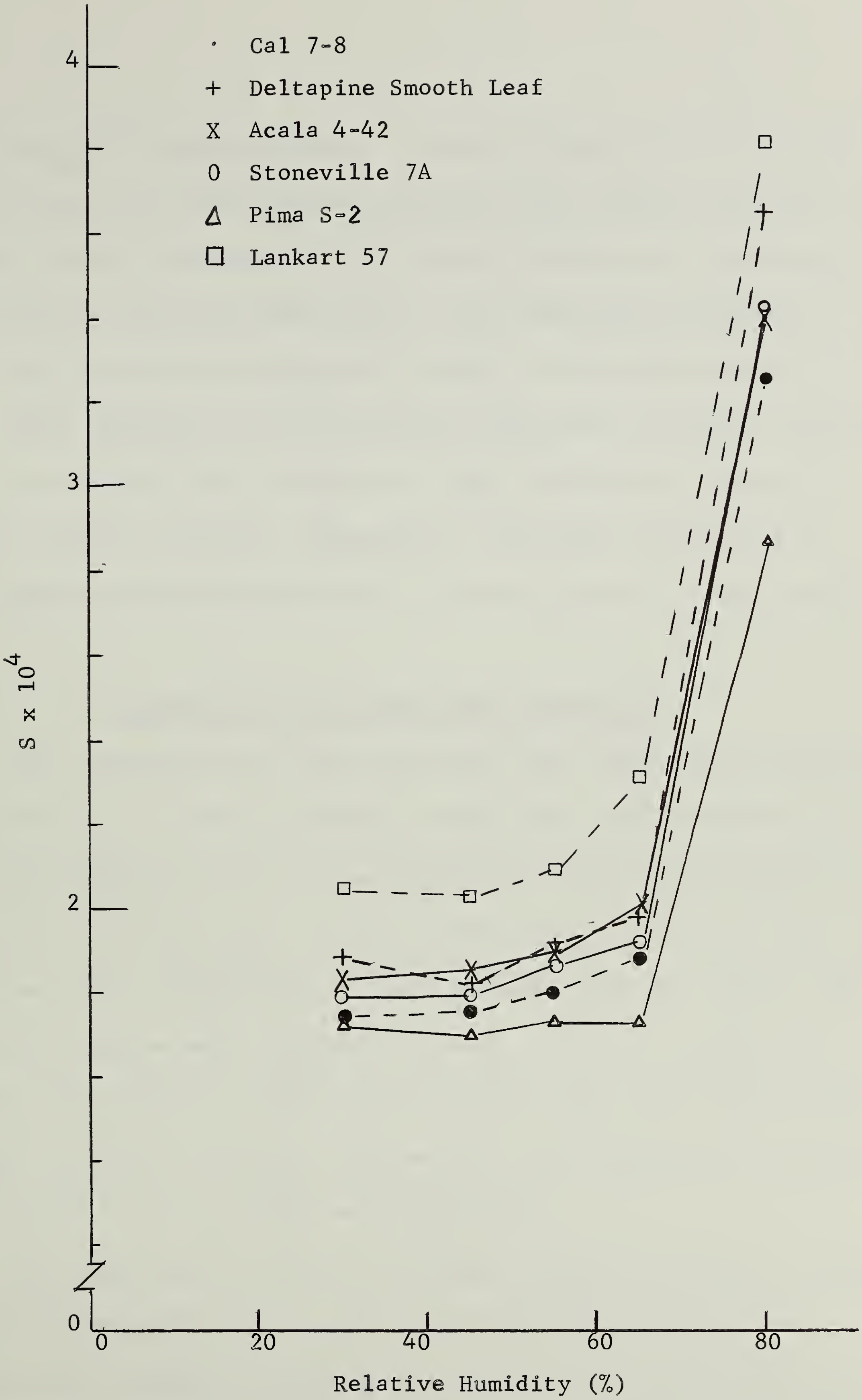


Figure 11. The effect of relative humidity on "shear friction".

in Table XIII, was some hysteresis. A typical example of this is shown in Figure 12 for Cal 7-8. The plots show that the sample treated at 100°C had a similar hysteresis to the control and that the hysteresis effect is greater than the effect due to the temperature treatment.

One set of control laps was carded at 50% RH and another at 55% RH. There appeared to be a measurable difference in "shear friction" between laps carded at 50% and 55% RH. These differences, shown in Figure 13, were not large but unexpected. The curves for the 100°C treated samples show that they follow a similar pattern to the control.

Correlation with Other Fiber Properties

The correlation of "shear friction" with other fiber properties was calculated and the results shown in Table XIV. The correlation with toughness was always very low. The correlation with 50% span length was significant at the 0.01 level. The correlation with 2.5% span length was lower but was still significant at the 0.01 level when the control and 180°C treated samples were combined, although it was not significant with either the control or 180°C treated samples when taken separately. When taken separately, only the correlations with Arealometer D, stiffness, 50% span length and x-ray angle were significant.

The high correlation with stiffness (T_1/E_1) as compared to the lower correlations with both T_1 and E_1 and the almost non-existent correlation with toughness, $(T_1E_1)/2$, indicate that the "shear friction" is more closely aligned with a combination of strength and elongation which describes a fiber elastic modulus. The high correlation with x-ray

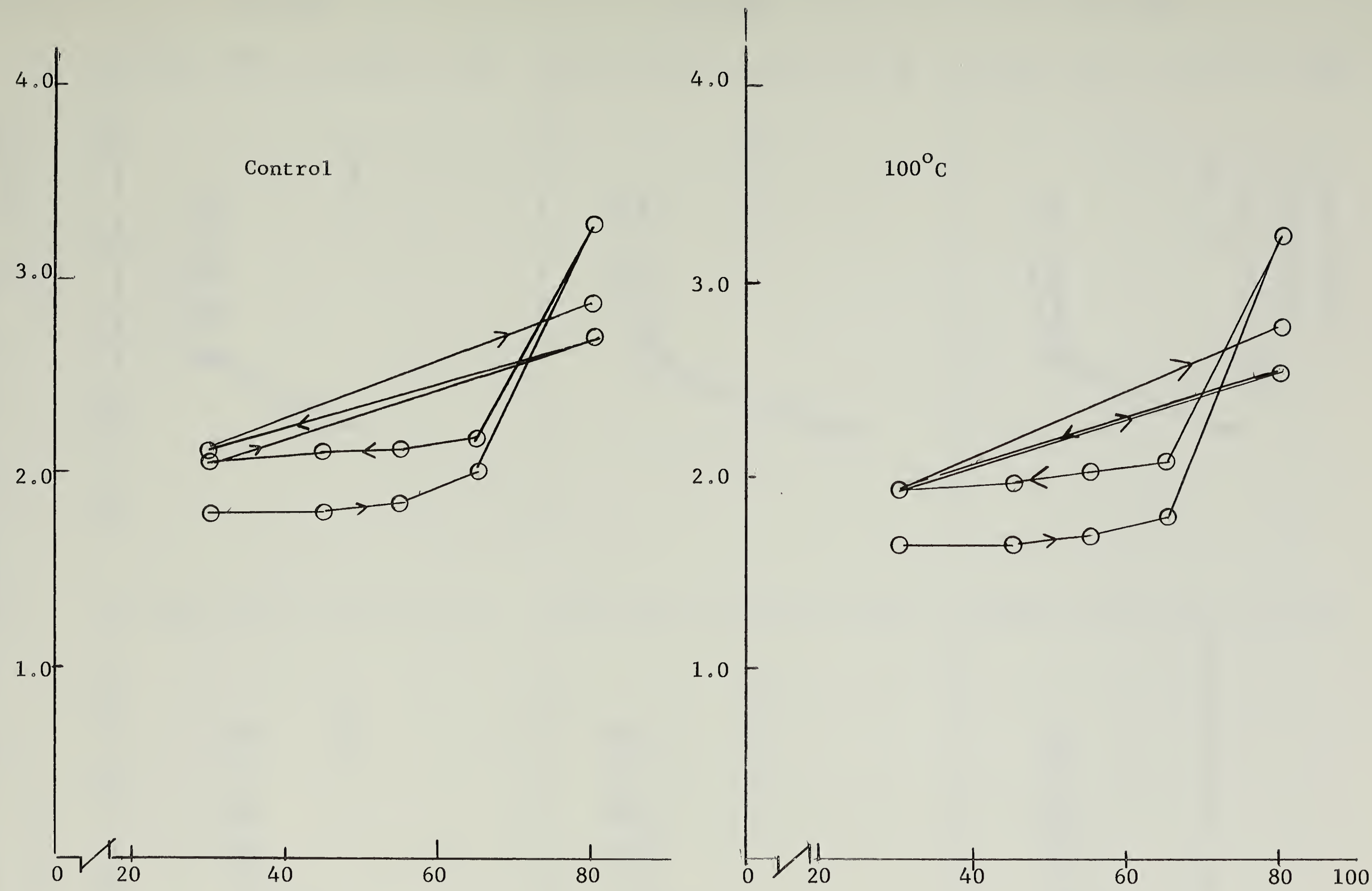


Figure 12. "Shear friction" hysteresis as a result of cycling the relative humidity on Cal 7-8.

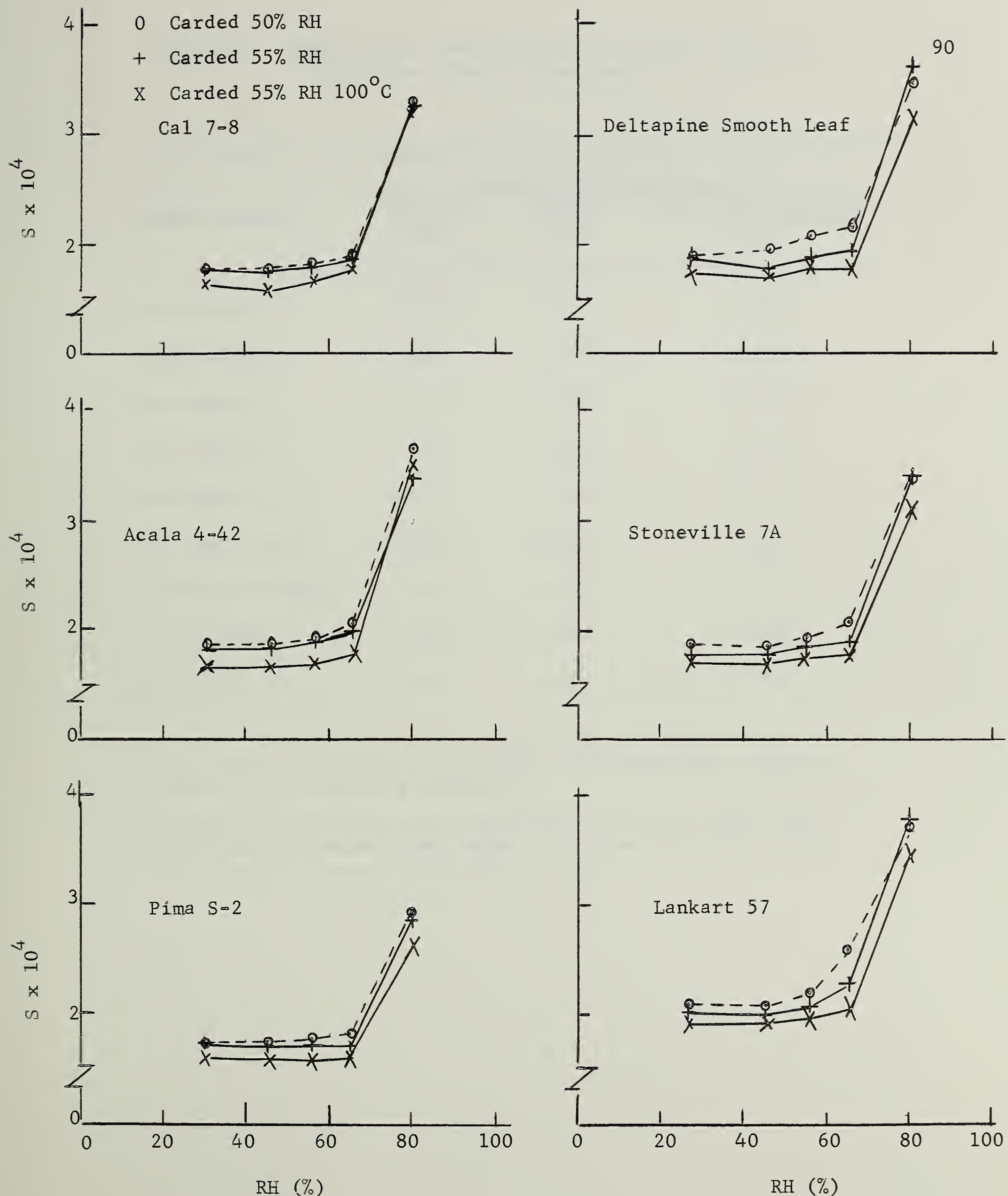


Figure 13. The effect of relative humidity on "shear friction" of samples carded and tested at various humidities.

TABLE XIV. Correlation Coefficients for "Shear Friction" with Other Fiber Properties.[1]

Fiber Property	Correlation Coefficients[2]		
	Control n=6	180°C n=6	All Data Combined n=12
Arealometer A	0.723	0.618	0.657
Arealometer D	0.869	0.750	0.797
Stelometer T_1	-0.726	-0.688	-0.690
Stelometer E_1	0.597	0.667	0.632
Stiffness T_1/E_1	-0.829	-0.853	-0.830
50% Span Length	-0.924	-0.929	-0.910
2.5% Span Length	-0.750	-0.778	-0.758
X-ray Angle	0.862	0.876	0.840
Tou. $(T_1E_1)/2$	-0.284	-0.162	-0.209

[1]The correlation coefficients were calculated with averages from all six varieties combined.

[2]Values of r required for significance are 0.576 and 0.708 for 5% and 1% respectively when n = 12 and 0.811 and 0.917 for 5% and 1% respectively when n = 6.

angle tells a similar story. The high correlation of "shear friction" with length may be similar to the type of correlation between strength and length of fiber and will need further study before it can be completely understood.

SECTION VII

SUMMARY AND CONCLUSIONS

This investigation has led to the following conclusions for the varieties to which modifications and treatments were applied.

Effects of Chemical Modifications and Atmospheric Changes on Fiber Properties

1. Crystallinity was increased with high temperature modification as indicated by an increase in density and a decrease in moisture regain.

2. Crystallinity was decreased by high humidity modification and by boiling in alcohol as indicated by a density decrease. This was possibly caused by the high temperature of the alcohol treatment instead of the alcohol as such.

3. A crystallinity change was induced by the chemical action of the NaOH modification as indicated by increased moisture regain, decreased density and a decreased x-ray angle; the latter being an indication of removal of the convolutions in addition to other structural changes.

4. Tenacity was generally decreased by high temperature modification (with the exception of Lankart 57). However, neither elongation nor toughness was altered by the high temperature modification.

5. The 50% span length was affected only very slightly by the atmospheric modifications. Lankart 57 was affected most drastically. The 2.5% span length was affected less than the 50% span length.

6. The Arealometer fineness value was affected very little by the atmospheric modifications. The only significant differences were shown in Cal 7-8 which increased for the higher humidities and higher temperatures and in Acala 4-42 which decreased for the 65% RH-72^{O}C and 80% RH-72^{O}C modifications.

7. The high temperature modifications generally resulted in fiber damage as indicated by high ACV. The surface treatment by boiling in alcohol caused a low ACV.

8. The apparent fineness (Arealometer, A,) was reduced by removing some of the surface waxes by boiling in alcohol except for Pima S-2 and Cal 7-8. Also, the boiling in alcohol resulted in a general increase in tenacity and decrease in elongation with no resultant change in toughness. This treatment generally lowered the length values. The 50% span lengths were lowered much more than the 2.5% span lengths.

9. The variability in friction measurements indicated that the coefficient of friction is dependent upon the normal force.

10. The various modifications affected each variety in a very similar way. ACV and immaturity value seemed to vary most widely from one variety-modification combination to another.

11. Pima S-2 stood out far above the other varieties in toughness, impact strength, tenacity and length.

12. Cal 7-8 was second next to Pima S-2 in tenacity, impact strength and 50% span length and was highest in length uniformity. However, it was lowest in elongation and was very low in toughness value. It also was lowest in fineness value, immaturity value and ACV. The latter indicates that it suffered the least damage due to the modifications.

13. Lankart 57 was highest in elongation, fineness, ACV and immaturity and lowest in tenacity, impact strength and length and length uniformity.

14. The correlations among the physical parameters showed that: a. moisture regain was correlated with density; b. density was poorly correlated with all other parameters; c. 50% x-ray angle was correlated highly with every parameter except toughness, density and moisture regain (all varieties combined); d. tenacity and impact strength were correlated with all other parameters except elongation, fineness, density and moisture regain; e. the correlations of elongation with the other parameters seem to be affected by the initial characteristics of the fibers before modification.

Effects of High Compressive Stresses at Various Humidities

1. Crushing did not materially change the relative differences within varieties due to modifications as compared to samples which were not crushed.

2. Crushing seemed to reduce the differences from one modification to another; however, the same general picture was seen with crushing as was seen with the modifications alone.

3. The following effects were produced from the applied crushing levels (no crushing, 17,000 psi, 50,000 psi, and 150,000 psi): a. tenacity decreased as crushing level increased; b. elongation increased with crushing pressure; however, Deltapine Smooth Leaf gave the only significant increase from 50,000 to 150,000 psi crushing pressure; c. there was a general increase in toughness with increased crushing except for the highest level. However, there were few significant differences except

from no crushing to 17,000 psi; d. the 50% and 2.5% span lengths decreased significantly with crushing level except from no crushing to 17,000 psi, where in some cases there was an increase; e. fineness decreased, generally, with increased crushing pressure. The largest drop was from no crushing to the 17,000 psi. Except for Cal 7-8 no significant difference was seen from 50,000 to 150,000 psi; f. immaturity values decreased significantly from no crushing to the first crushing level with only a small drop with higher crushing pressures; g. the ACV increased significantly from no crushing to 17,000 psi except for Lankart 57 and from 17,000 to 50,000 psi except for Lankart 57 and Deltapine Smooth Leaf. No difference was seen between the two higher crushing pressures.

4. Each parameter, except immaturity value, was affected more drastically by the crushing at 35% RH than at the two higher humidities. Tenacity, elongation, toughness, fineness and immaturity value were affected about the same at 65% and 80% RH.

5. Increasing humidity during crushing caused increased tenacity, elongation, toughness, impact strength and length and decreased fineness, and ACV as compared with the same parameters obtained at the lowest humidity.

6. The correlations among the physical parameters as a result of crushing (omitting the alcohol and NaOH modifications) showed that: a. correlations as a result of crushing with all varieties combined were similar to the correlations with no crushing except for those with fineness, immaturity value and ACV; b. tenacity and impact strength were both negatively correlated with ACV. Pima S-2 and Cal 7-8 had the highest correlations; these correlations for Lankart 57 were not significant;

c. impact strength and fineness value were poorly correlated; d. tenacity and fineness werecorrelated for each variety as altered by the modifications; however, when the data for all varieties werecombined, there was low correlation; e. tenacity and impact strength were both well correlated with length; f. tenacity and impact strength had low correlations with toughness for each variety separately but these correlations were high positive when all varieties were combined; g. the elongation-impact strength correlations were low. The elongation-tenacity correlations were high (-0.50±) with the highest being for Pima S-2 and Cal 7-8; h. the elongation-toughness correlations were very high - an increase over those with no crushing; i. the elongation-length correlations were negative for some varieties and positive with others. Only two correlations were as high as 0.40; j. elongation-fineness and elongation-immaturity correlations were usually negatively high; k. toughness-length correlations were high for Deltapine Smooth Leaf and Pima S-2; l. toughness-fineness correlations were negative high except for Pima S-2; m. toughness-ACV correlations were always low.

7. Crushing altered tenacity, impact strength and span lengths more strongly with the alcohol boiled.

8. The least affected modification due to crushing was the NaOH.

9. Within the atmospherically treated samples the most drastic effect due to crushing was within the 180°C modifications.

10. The variety affected most by crushing was Cal 7-8.

11. The least affected variety due to crushing was Lankart 57.

12. The 50% span length was always affected more due to crushing than the 2.5% span length.

Effects of Mechanical Working at Various Humidities

1. Compared with the modification effects without mechanical working, the mechanical working caused the following changes in fiber properties (Table C-II): a. tenacity for all varieties showed a significant decrease for the 180°C modification; b. elongation significantly decreased for all varieties except Acala 4-42 with the 180°C modifications; c. toughness was significantly lowered for all varieties with the 180°C and the alcohol modifications; d. impact strength was more variable and lower for Stoneville 7A with the 35% RH-180°C modification; e. the 50% span length was reduced significantly for Stoneville 7A with the 35% RH-180°C modification and, compared to the samples without mechanical working, the alcohol modification gave a more drastic reduction for all varieties.

2. Mechanical working caused: a. an increase in tenacity and impact strength; b. a general elongation decrease; c. a decrease in length; d. a decrease in fineness; e. a general decrease in immaturity value; f. an increase in ACV.

3. Mechanical working at various humidities showed that: a. tenacity and impact strength generally decreased as the relative humidity of mechanical working decreased and more drastically at the lower humidities; b. the length tended to decrease with decreasing humidity; however, within the limits of this investigation, not usually signficantly; c. the ACV increased as relative humidity decreased for Cal 7-8, Deltapine Smooth Leaf and Lankart 57.

4. The correlations between the physical parameters resulting form mechanical working (omitting the alcohol and NaOH modifications)

showed that: a. the data from all varieties combined produced correlations very similar to those with no mechanical working; b. correlations for the data from mechanically worked samples were often different from correlations from the crushed samples; c. the correlations for the data from all varieties combined were often different from those within one variety. This applied in some degree to all varieties.

Effects of Some Harsh Treatments on Fiber Spinnability

Torsion, twisting and roping.

1. The torsional stiffness results showed that: a. high temperature, alcohol and NaOH modifications all tended to increase the torsional stiffness; b. Pima S-2, unmodified, had the lowest torsional stiffness of the three varieties tested; however, it had the greatest increase due to the modifications; c. Deltapine Smooth Leaf was affected least by the high temperature and alcohol modifications; d. Cal 7-8 had the highest initial torsional stiffness of the three varieties tested but was not affected as much by the modifications as Pima S-2.

2. The twisting and roping results showed that: a. Pima S-2 produced the greatest twisting and roping of the three varieties tested. Deltapine Smooth Leaf produced the next highest values. This possibly reflects the low torsional stiffness, as well as differences in length of fiber; b. the highest values for twisting and roping resulted from the unmodified samples. A reduced value was produced from the high temperature modification. The lowest value was produced from the NaOH modification.

Fiber properties in processing.

1. Within the varieties tested and within modifications, processing had little effect on fiber tenacity except within Pima S-2.

2. Elongation tended to increase from no processing to second drawing with a reduction to its approximate original elongation at spinning.

3. Toughness decreased with processing for Pima S-2.

4. 50% span length was not changed as it progressed through processing. 2.5% span length tended to decrease with Pima S-2 and Deltapine Smooth Leaf with processing.

5. ACV increased from no processing to second drawing with usually no further increase from second drawing to spinning.

Yarn characteristics.

1. The yarn strength was reduced by boiling in alcohol (removing the wax), by high temperature modification, and by treatment in NaOH in that order.

2. Yarn strength variability was lowest (for the varieties tested) for the highest yarn strength and highest for the lowest yarn strength.

3. Yarn elongation was the same for Pima S-2 and Deltapine Smooth Leaf and they were both different from Cal 7-8 which was lower. Yarn elongation effect due to modifications in increasing order was boiled in alcohol, 65% RH-180^{o}C, control and NaOH.

4. Neither the fiber elongation nor the fiber strength of the NaOH modified samples was completely transferred to the yarn. The yarn elongation for all except the NaOH modification was about 25% lower than

the fiber elongation and the yarn elongation for the NaOH modification was about 55% lower than the fiber elongation (see Figure 12).

5. Yarn appearance was poorest in the Deltapine Smooth Leaf and the samples boiled in alcohol.

6. Pima S-2 gave the highest yarn abrasion value and Deltapine Smooth Leaf the lowest. Each of the modifications tested reduced the yarn abrasion value, with the samples boiled in alcohol being the lowest.

7. Yarn linear density variability was lowest in Pima S-2 and highest in Deltapine Smooth Leaf. Of the modifications, the control and the 65% RH-180°C modification were not different. The samples boiled in alcohol were the highest.

Effects of Atmospheric Changes on Interfiber Action

1. "Shear friction" was reduced when cotton was heated above the melting point of wax but increased again when the temperature was further raised to cause wax disintegration.

2. "Shear friction" varied slightly with humidity between 30% RH and 65% RH but increased sharply between 65% RH and 80% RH.

3. "Shear friction" was especially related to parameters describing the internal structure and the elastic moduli of the fibers as indicated by the correlation values.

Special Variety and Modification Effects

The lists given below provide some of the more outstanding effects of the various varieties and modifications.

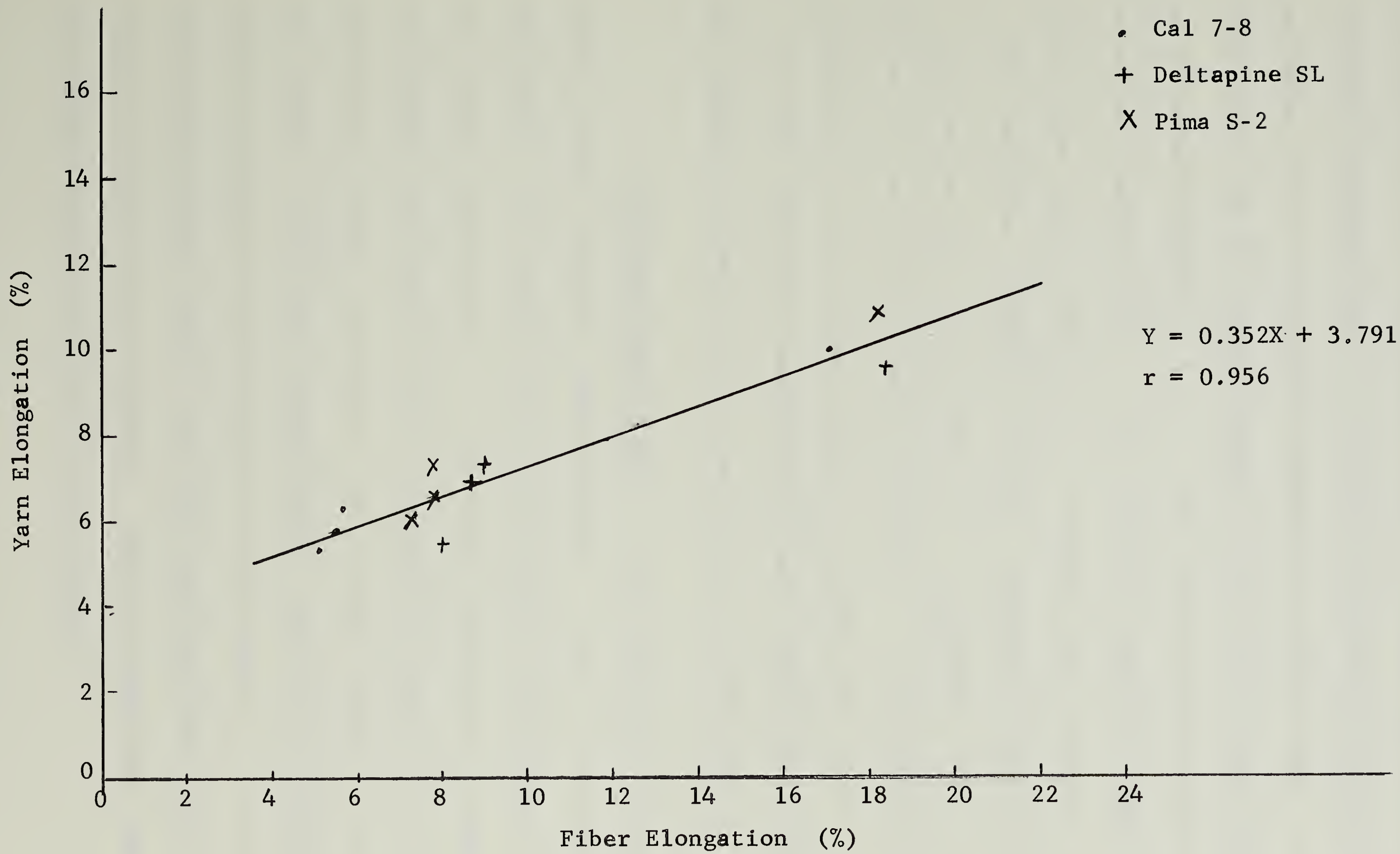


Figure 14. The relationship of fiber elongation and yarn elongation on three varieties with four modifications each.

Varietal effects.

1. Cal 7-8: a. the fineness, A, value increased with temperature modification; b. the immaturity value, D, showed some scatter among the atmospheric modifications; c. the ACV was lower for the NaOH modification and higher for the 35% RH-180°C temperature modification; d. the alcohol modification did not change fineness, A, but did increase tenacity, T_1, and decreased elongation, E_1; e. there was no length reduction due to the alcohol modification; f. the values for tenacity, impact strength, and 50% span length were next to the highest and just below Pima S-2; g. the elongation, toughness, fineness, immaturity value and ACV were low; h. this was the only variety which had a significant drop in fineness between the two higher crushing pressures; i. the tenacity-elongation correlation for the crushed samples was highest with Cal 7-8 and Pima S-2; j. the 180°C and alcohol modifications were significantly different with the toughness parameter for the mechanically worked samples.

2. Deltapine Smooth Leaf: a. the immaturity value showed some scatter among atmospheric modifications; b. the ACV was higher with the 35% RH-180°C, 65% RH-180°C and the 35% RH-72°C modifications and lower for the NaOH modification; c. the alcohol modification caused a decrease in fineness and elongation and an increase in tenacity; d. the alcohol modification caused a decrease in the 50% span length but not in the 2.5% span length; e. for the crushed samples, there was no significant increase in elongation from 50,000 psi to 150,000 psi; f. for the mechanically worked samples, the 180°C modifications caused a significant change in elongation and toughness. Impact strength was lower for the 35% RH-180°C modification than for the control.

3. Acala 4-42: a. the alcohol modification decreased the fineness value and elongation and increased tenacity; b. the 50% span length was lowered due to the alcohol modification but the 2.5% span length was not; c. for the mechanically worked samples, toughness was significantly different from the control for the 180°C and alcohol modifications.

4. Stoneville 7A: a. the alcohol modification caused a decrease in fineness and elongation and an increase in tenacity; b. the 180°C modifications significantly reduced the toughness; c. the 50% and 2.5% span length were both reduced due to the alcohol modification; d. for the mechanically worked samples toughness was reduced significantly on the 180°C and alcohol modifications and the 50% span length was reduced on the 35% RH-180°C modification.

5. Pima S-2: a. the immaturity value showed some scatter among atmospheric modifications; b. the ACV was higher for the 180°C modifications and lower for the NaOH modifications; c. the 50% span length changed due to the 35% RH-180°C and alcohol modifications; d. this variety was high in tenacity, toughness, impact strength and length; e. the tenacity-elongation correlations were high; f. for the mechanical working samples, toughness was significantly different with the 180°C and alcohol modifications.

6. Lankart 57: a. tenacity was not decreased by the 180°C modifications but were for all other varieties; b. the 50% span length was affected more drastically among the modifications than with the other varieties; c. alcohol modification decreased fineness and elongation and

increased tenacity; d. the 50% and 2.5% span lengths were changed significantly due to the alcohol modification; e. this variety had the highest elongation, fineness, immaturity and ACV and was lowest in tenacity, impact strength and length; f. this variety had the lowest ACV increase due to crushing; g. for the mechanically worked samples, the tenacity showed a significant difference due to the 180°C modifications. Toughness showed a significant difference due to the 180°C and alcohol modifications.

Modification effects.

1. 80% RH-72°C Modifications: a. density increased; b. the fineness value decreased for Acala 4-42.

2. 35% RH-180°C Modification: a. density increased and moisture regain decreased; b. tenacity decreased except for Lankart 57; c. there was a decreasing trend for impact strength. Only in Pima S-2 was the decrease significant; d. ACV was high except for Lankart 57.

3. 65% RH-180°C Modification: a. density increased and moisture regain decreased; b. tenacity decreased except for Lankart 57; c. ACV was high for Cal 7-8, Deltapine Smooth Leaf and Pima S-2.

4. Modification by Boiling in Alcohol: a. density increased; b. ACV was low for Acala 4-42, Stoneville 7A, Pima S-2 and Lankart 57; c. 50% span length was reduced except for Cal 7-8; d. 2.5% span length was reduced for Lankart 57, Stoneville 7A and Deltapine Smooth Leaf; e. generally the significant effect on varieties increased as initial maturity and fineness increased.

5. NaOH Modification: a. density and x-ray angle decreased and moisture regain increased; b. ACV was low on all varieties; c. fineness,

immaturity and length values were reduced; d. tenacity, impact strength, elongation and toughness increased.

General Conclusions

1. High temperature and low humidity modifications affect the cotton fiber detrimentally. These modifications stand out in crushing and processing because of the increased fiber damage and less desirable yarn properties.

2. A treatment which changes elongation and/or tenacity so as to decrease the end use value of the fiber may either increase or decrease the toughness value. Therefore, the actual value of the toughness value, as determined here, is questioned.

3. Elongation is a very significant fiber characteristic with respect to yarn properties, but it must be associated with tenacity, length and other fiber properties to produce an overall desirable result.

4. Fibers of low torsional stiffness can be expected to increase in twisting and roping; however, some of the low torsional stiffness seems to be characteristic of the more desirable cottons.

5. There is a limit to the desirable friction for the surface of a fiber.

Recommendations

The results and conclusions of this investigation have led to the following recommendations.

1. An appropriate test method for predicting potentials of cotton fibers for breakage in processing would consist of an appropriate

series of treatments which would work the fibers to a maximum extent in a process similar to that which takes place in a carding machine. Comparison of fiber tests before and after the working would determine the relative potential of the cotton fibers in question for breakage in processing.

2. This investigation has led to further work which has produced a promising test apparatus and method for predicting the processing performance of cottons varying in fiber structure and surface characteristics. This device along with the applicable test methods measures the "shear energy" and has been described by Hertel (11,12). The measurement is dependent upon the fiber surface characteristics, as well as the strength and elastic characteristics and may be a possible way of obtaining a definite physical determination for the "character" which the cotton classer feels in a sample. The apparatus and the test methods are still in the development stage.

3. The optimum conditions for processing cottons of different extensibilities has been concluded to be a strong factor of humidity. Except in rare cases the minimum detrimental effect on the fiber has been with the higher humidities. There is a limit, however, which causes difficulty due to the sticking of the fibers to each other and to the machinery. It is therefore recommended that the processing be carried out at the highest humidity possible within the limits of the difficulty due to dampness.

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SECTION IX

APPENDIX A

FIBER MODIFICATION WITHOUT MECHANICAL TREATMENT

(Tables and Graphs)

TABLE A-I. Fiber Property Means for Each Cotton Variety and the Significance at the 5 Per Cent Level[1]

Variety	Impact		Tenacity		Elongation		Toughness		50% Span Length		2.5% Span Length	
Cal 7-8	20.08	B	22.42	B	6.97	E	0.810	D	0.519	B	1.052	D
DP-SL	17.67	D	19.72	D	10.02	A	0.990	B	0.485	D	1.114	B
A 4-42	18.94	C	21.37	C	8.70	C	0.954	B	0.502	C	1.084	C
St. 7A	15.95	E	18.57	E	7.85	D	0.740	E	0.472	E	1.115	B
P. S-2	27.01	A	29.03	A	9.22	B	1.336	A	0.583	A	1.302	A
L 57	15.48	E	17.19	F	10.07	A	0.876	C	0.392	F	0.958	E

Variety	X-ray		Density		Moisture Regain		ACV		Fineness		Immaturity	
Cal 7-8	27.68	D	1.5453	A	7.58	C	191.5	E	431.9	F	25.4	E
DP-SL	34.62	A	1.5416	E	7.43	D	201.7	D	441.9	E	29.5	D
A 4-42	30.80	B	1.5421	D	7.70	AB	212.2	B	502.0	B	47.1	B
St. 7A	30.05	C	1.5418	DE	7.73	A	210.4	C	479.6	D	41.6	C
P. S-2	26.90	E	1.5431	B	7.44	D	200.4	D	484.2	C	28.6	D
L 57	34.89	A	1.5425	C	7.64	BC	225.3	A	551.3	A	64.4	A

[1]These are the means within a variety of all the modifications without crushing or mechanical working.

TABLE A–II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(a) Density Means as Affected by the Modifications (g/cm^3)

Modification	Variety						All Varieties
	Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	
Control	1.5497 A	1.5442 D	1.5456 B	1.5460 B	1.5458 A	1.5468 C	1.5464 C
35%-72°C	1.5486 A	1.5446 CD	1.5455 B	1.5456 B	1.5464 A	1.5462 CD	1.5461 C
65%-72°C	1.5483 AB	1.5448 CD	1.5448 C	1.5446 C	1.5453 A	1.5456 DE	1.5456 D
80%-72°C	1.5468 B	1.5428 E	1.5430 D	1.5431 D	1.5444 A	1.5440 F	1.5440 E
35%-180°C	1.5494 A	1.5479 A	1.5475 A	1.5470 A	1.5476 A	1.5492 A	1.5481 A
65%-180°C	1.5496 A	1.5466 B	1.5472 A	1.5463 B	1.5474 A	1.5482 B	1.5476 B
Alcohol	1.5483 AB	1.5458 BC	1.5446 C	1.5440 C	1.5453 A	1.5454 E	1.5456 D
NaOH	1.5221 C	1.5163 F	1.5186 E	1.5178 E	1.5224 B	1.5144 G	1.5186 F

TABLE A–II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(b) Moisture Regain Means as Affected by the Modifications (%)

Modification	Variety												All Varieties	
	Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57			
Control	7.31	B	7.18	B	7.48	B	7.56	B	7.13	CD	7.40	BC	7.34	BCD
35%-72°C	7.26	B	7.12	B	7.40	B	7.44	B	7.06	D	7.28	C	7.26	D
65%-72°C	7.28	B	7.13	B	7.41	B	7.47	B	7.18	CD	7.35	BC	7.30	CD
80%-72°C	7.38	B	7.19	B	7.37	B	7.52	B	7.27	BC	7.43	BC	7.36	BC
35%-180°C	6.80	C	6.68	C	6.93	C	6.93	C	6.63	E	6.98	D	6.83	E
65%-180°C	6.84	C	6.64	C	6.92	C	6.82	C	6.69	E	6.89	D	6.80	E
Alcohol	7.36	B	7.26	B	7.53	B	7.59	B	7.35	B	7.52	B	7.44	B
NaOH	10.40	A	10.31	A	10.58	A	10.53	A	10.21	A	10.27	A	10.38	A

TABLE A–II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(c) X-ray Angle Means as Affected by the Modifications (^{o})

Modification	Variety: Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	All Varieties
Control	26.55 B	34.68 A	30.18 BC	31.90 A	26.88 B	36.72 AB	31.15 BCD
35%-72^{o} C	27.78 AB	34.18 A	31.12 ABC	30.95 A	27.75 AB	34.78 C	31.09 CD
65%-72^{o} C	28.32 AB	36.10 A	32.20 AB	30.90 A	29.18 A	35.75 BC	32.08 A
80%-72^{o} C	28.75 A	35.88 A	32.72 A	30.18 A	27.35 B	35.25 BC	31.69 ABCD
35%-180^{o} C	27.95 AB	34.85 A	31.90 AB	30.62 A	28.50 AB	37.90 A	31.95 AB
65%-180^{o} C	29.58 A	35.48 A	32.50 A	30.62 A	27.32 B	35.62 BC	31.85 ABC
Alcohol	28.30 AB	35.30 A	29.02 C	30.08 A	27.12 B	35.72 BC	30.92 D
NaOH	24.18 C	30.48 B	26.75 D	25.18 B	21.10 C	27.40 D	25.85 E

TABLE A-II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(d) Stelometer Tenacity Means as Affected by the Modifications (g/tex)

Modification	Variety: Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57		All Varieties	
Control	21.95	C	19.95	AB	20.75	CD	18.35	C	29.75	AB	16.50	B	21.21	C
35%-72°C	22.40	BC	19.85	AB	20.75	CD	18.35	C	29.35	ABC	16.55	B	21.21	C
65%-72°C	22.05	BC	19.90	AB	20.90	C	18.50	C	28.80	BC	16.55	B	21.12	C
80%-72°C	21.85	C	19.40	BC	20.90	C	18.35	C	29.40	AB	16.80	B	21.12	C
35%-180°C	21.10	D	18.85	C	20.15	D	17.80	CD	27.65	D	16.80	B	20.39	D
65%-180°C	20.80	D	19.00	C	20.40	CD	17.60	D	28.40	CD	16.60	B	20.47	D
Alcohol	22.75	B	20.45	A	22.10	B	19.35	B	30.00	A	18.65	A	22.22	B
NaOH	26.50	A	20.40	A	25.00	A	20.25	A	28.90	BC	19.05	A	23.35	A

TABLE A-II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(e) Per Cent Elongation Means as Affected by the Modifications (%)

Modification	Variety: Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57		All Varieties	
Control	5.66	B	9.05	BC	7.64	B	6.68	B	7.85	B	9.00	B	7.65	B
35%-72°C	5.62	B	9.35	B	7.50	BC	6.66	B	8.20	B	9.12	B	7.74	B
65%-72°C	5.45	B	8.88	BC	7.46	BC	6.68	B	8.32	B	8.86	B	7.61	B
80%-72°C	5.72	B	8.90	BC	7.55	BC	6.70	B	8.14	B	9.12	B	7.69	B
35%-180°C	5.56	B	8.90	BC	7.18	BC	6.40	BC	7.90	B	9.25	B	7.53	B
65%-180°C	5.52	B	8.68	BC	7.10	BC	6.54	BC	7.82	B	9.04	B	7.45	B
Alcohol	5.08	B	8.01	C	6.58	C	6.25	C	7.34	B	8.00	C	6.88	C
NaOH	17.12	A	18.35	A	18.55	A	16.91	A	18.18	A	18.16	A	17.88	A

TABLE A-II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(f) Toughness Means as Affected by the Modifications (g/tex)

Modification	Variety						All Varieties
	Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	
Control	0.622 B	0.902 BC	0.792 B	0.614 B	1.170 B	0.742 B	0.807 B
35%-72°C	0.627 B	0.924 B	0.774 B	0.612 B	1.202 B	0.754 B	0.815 B
65%-72°C	0.603 B	0.885 BC	0.780 B	0.617 B	1.195 B	0.735 B	0.803 B
80%-72°C	0.624 B	0.862 BC	0.788 B	0.612 B	1.195 B	0.768 B	0.808 B
35%-180°C	0.585 B	0.836 C	0.725 B	0.568 C	1.088 B	0.780 B	0.764 B
65%-180°C	0.572 B	0.823 C	0.725 B	0.578 C	1.110 B	0.753 B	0.760 B
Alcohol	0.578 B	0.820 C	0.730 B	0.605 B	1.102 B	0.743 B	0.763 B
NaOH	2.270 A	1.868 A	2.315 A	1.714 A	2.628 A	1.735 A	2.088 A

TABLE A-II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(g) Impact Strength Means as Affected by the Modifications (g/tex)

Modification	Variety												All Varieties	
	Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57			
Control	19.06	B	17.25	B	18.22	B	15.41	B	26.86	BC	14.93	B	18.62	BC
35%-72°C	19.35	B	17.08	B	18.10	B	15.57	B	26.45	BC	15.21	B	18.63	BC
65%-72°C	19.10	B	17.25	B	18.20	B	15.15	B	26.87	BC	15.25	B	18.64	BC
80%-72°C	19.35	B	17.68	B	18.10	B	15.28	B	26.47	BC	15.16	B	18.68	BC
35%-180°C	18.35	B	16.96	B	17.08	B	14.74	B	24.92	C	14.50	B	17.76	D
65%-180°C	18.34	B	16.52	B	17.20	B	14.93	B	26.02	BC	14.55	B	17.93	CD
Alcohol	19.52	B	17.55	B	18.97	B	15.78	B	27.48	B	15.22	B	19.09	B
NaOH	27.60	A	21.02	A	25.68	A	20.74	A	31.02	A	19.02	A	24.18	A

TABLE A-II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(h) 50 Per Cent Span Length Means as Affected by the Modifications (in.)

Modification	Variety: Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	All Varieties
Control	0.530 A	0.493 AB	0.517 A	0.482 A	0.605 A	0.403 AB	0.505 A
35%-72°C	0.530 A	0.495 A	0.522 A	0.487 A	0.598 AB	0.408 A	0.507 A
65%-72°C	0.535 A	0.498 A	0.520 A	0.485 A	0.605 A	0.396 BC	0.507 A
80%-72°C	0.538 A	0.500 A	0.518 A	0.484 A	0.598 AB	0.400 ABC	0.506 A
35%-180°C	0.525 A	0.484 AB	0.504 AB	0.468 AB	0.578 B	0.400 ABC	0.493 B
65%-180°C	0.518 A	0.490 AB	0.496 ABC	0.485 A	0.585 AB	0.392 C	0.494 B
Alcohol	0.518 A	0.470 BC	0.475 BC	0.450 BC	0.578 B	0.358 E	0.475 C
NaOH	0.456 B	0.448 C	0.465 C	0.437 C	0.516 C	0.378 D	0.450 D

TABLE A-II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(i) 2.5 Per Cent Span Length Means as Affected by the Modifications (in.)

Modification	Variety						All Varieties
	Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	
Control	1.068 A	1.138 A	1.105 A	1.140 A	1.335 A	0.978 A	1.128 A
35%-72°C	1.068 A	1.137 A	1.110 A	1.143 A	1.324 A	0.982 A	1.127 A
65%-72°C	1.070 A	1.132 A	1.104 A	1.142 A	1.326 A	0.980 A	1.126 AB
80%-72°C	1.077 A	1.138 A	1.110 A	1.138 A	1.328 A	0.978 A	1.128 A
35%-180°C	1.070 A	1.130 AB	1.095 A	1.132 A	1.313 A	0.978 A	1.120 B
65%-180°C	1.064 A	1.128 AB	1.098 A	1.134 A	1.325 A	0.972 A	1.120 B
Alcohol	1.068 A	1.117 B	1.090 A	1.108 B	1.315 A	0.936 B	1.106 C
NaOH	0.927 B	0.988 C	0.960 B	0.986 C	1.153 B	0.862 C	0.979 D

TABLE A-II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(j) Fineness Means as Affected by the Modifications (mm^{-1})

Modification	Variety						All Varieties
	Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	
Control	442.5 B	456.8 A	522.4 AB	496.0 A	496.5 A	573.7 A	498.0 A
35%-72°C	442.1 B	458.5 A	519.2 AB	496.2 A	505.2 A	576.6 A	499.6 A
65%-72°C	449.3 A	457.3 A	517.8 B	500.8 A	501.9 A	575.6 A	500.5 A
80%-72°C	445.0 AB	460.4 A	518.5 B	498.4 A	496.1 A	574.0 A	498.7 A
35%-180°C	445.0 AB	457.4 A	524.9 A	498.8 A	496.7 A	581.7 A	500.8 A
65%-180°C	445.7 AB	459.7 A	521.8 AB	504.2 A	499.7 A	576.1 A	501.2 A
Alcohol	441.0 B	446.3 B	511.8 C	483.5 B	498.5 A	557.6 B	489.8 B
NaOH	345.0 C	338.8 C	379.5 D	358.8 C	379.1 B	395.1 C	366.0 C

TABLE A–II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(k) Immaturity Means as Affected by the Modifications (mm^{-1})

Modification	Variety												All Varieties	
	Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57			
Control	28.6	AB	36.8	A	52.8	A	47.8	A	30.4	B	71.6	A	44.7	AB
35%-72°C	31.6	AB	36.0	A	57.3	A	48.6	A	30.9	B	75.5	A	46.6	A
65%-72°C	33.1	A	33.1	AB	53.4	A	48.4	A	33.4	AB	74.4	A	46.0	AB
80%-72°C	29.0	AB	36.2	A	52.3	A	46.1	A	37.5	A	74.1	A	45.9	AB
35%-180°C	28.9	AB	30.1	B	55.1	A	47.4	A	33.4	AB	73.9	A	44.8	AB
65%-180°C	25.8	B	33.1	AB	55.1	A	46.1	A	31.3	AB	71.2	A	43.8	B
Alcohol	16.1	C	23.2	C	40.2	B	36.2	B	22.8	C	57.7	B	32.7	C
NaOH	9.9	D	7.6	D	10.5	C	11.8	C	9.4	D	16.4	C	10.9	D

TABLE A-II. Effect of Modification on Fiber Properties and the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(1) Alkali Centrifuge Value Means as Affected by the Modifications (%)

Modification	Variety												All Varieties	
	Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57			
Control	191.1	BC	201.0	C	211.5	B	211.9	ABC	198.1	B	226.6	AB	206.7	BC
35%-72°C	190.3	C	202.3	ABC	213.2	B	213.5	A	199.2	B	230.5	A	208.2	B
65%-72°C	191.3	BC	200.9	C	212.9	B	212.6	AB	197.0	BC	229.3	A	207.3	BC
80%-72°C	192.1	BC	201.8	BC	215.1	AB	210.1	C	197.7	B	230.1	A	207.8	B
35%-180°C	197.6	A	206.8	A	217.1	A	212.4	ABC	207.7	A	228.9	AB	211.7	A
65%-180°C	195.4	AB	205.9	AB	214.6	AB	213.1	AB	209.4	A	225.2	AB	210.6	A
Alcohol	191.7	BC	204.0	ABC	207.0	C	210.6	BC	200.0	B	223.0	B	206.1	C
NaOH	182.7	D	191.2	D	206.6	C	198.6	D	194.0	C	208.7	C	197.0	D

TABLE A-III. Correlation Coefficients of Combinations of Properties on Six Varieties With Seven Modifications Each [1,2]

Property	MR	Den	X-ray	Imp. St.	T_1	E_1	Tou	50% SL	2.5% SL	A	D
ACV	0.09	-0.19	0.65	-0.55	-0.59	0.52	-0.14	-0.74	-0.50	0.90	0.92
D	0.20	-0.14	0.60	-0.56	-0.61	0.46	-0.20	-0.71	-0.58	0.90	
A	0.17	-0.18	0.43	-0.24	-0.30	0.50	0.09	-0.54	-0.33		
2.5% S.L.	-0.24	-0.22	-0.59	0.84	0.85	-0.01	0.73	0.87			
50% S.L.	-0.23	0.04	-0.77	0.86	0.88	-0.30	0.54				
Tou.	-0.24	-0.28	-0.13	0.79	0.74	0.56					
E_1.	-0.17	-0.36	0.70	-0.04	-0.13						
T_1.	-0.15	-0.02	-0.72	0.99							
Imp. St.	-0.17	-0.01	-0.67								
X-ray	-0.02	-0.20									
Den.	-0.51										

[1] These samples received no mechanical treatment and the NaOH modification was omitted.

[2] The total number of paired observations is 42 with two sets of subgroups consisting of six varieties and seven modifications. For 42 paired values r = 0.30 is significant at the 0.05 level.

Figure A-1. Variety modification interaction for toughness, 50% span length, 2.5% span length, impact strength, tenacity and elongation (no mechanical treatment).

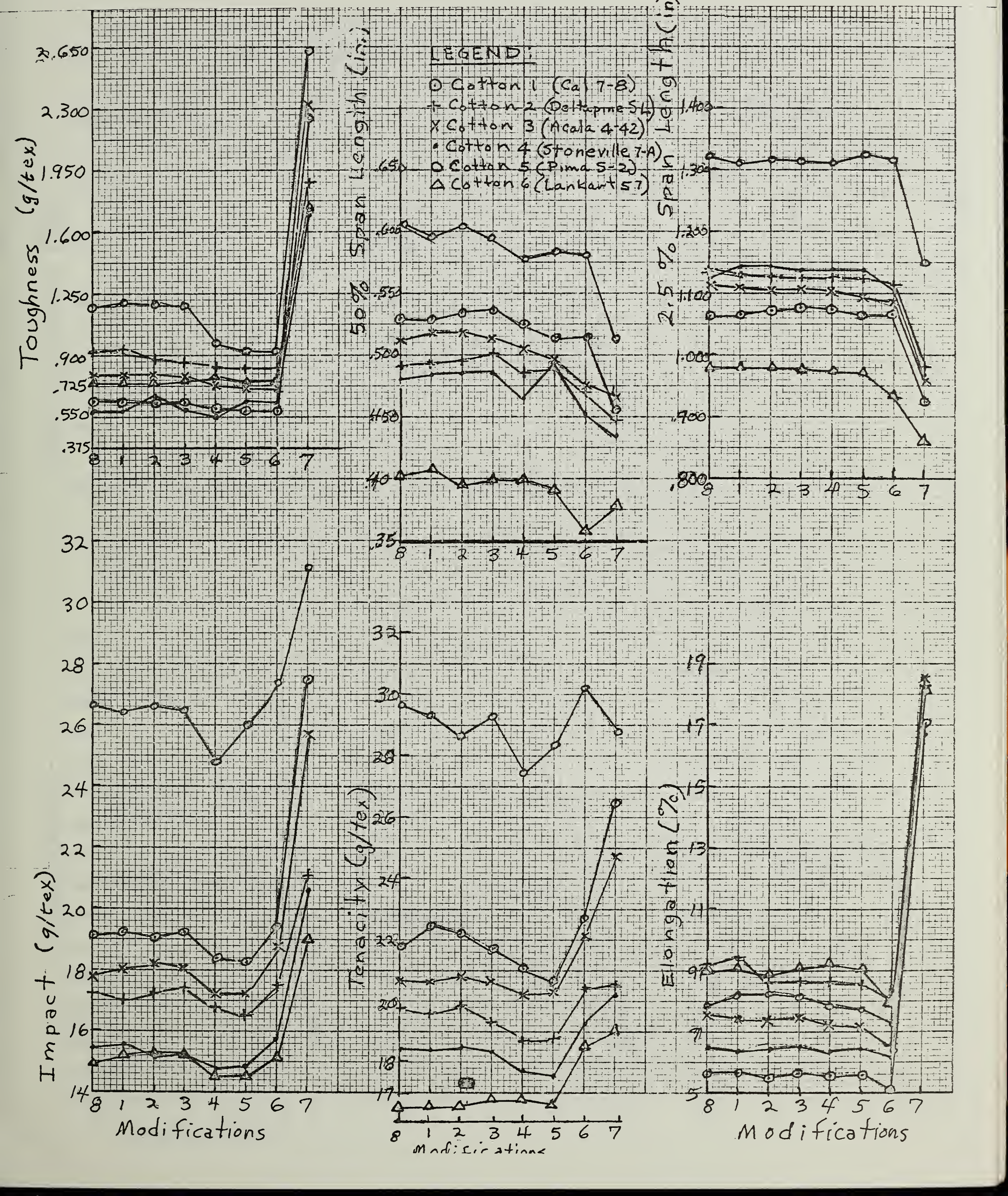
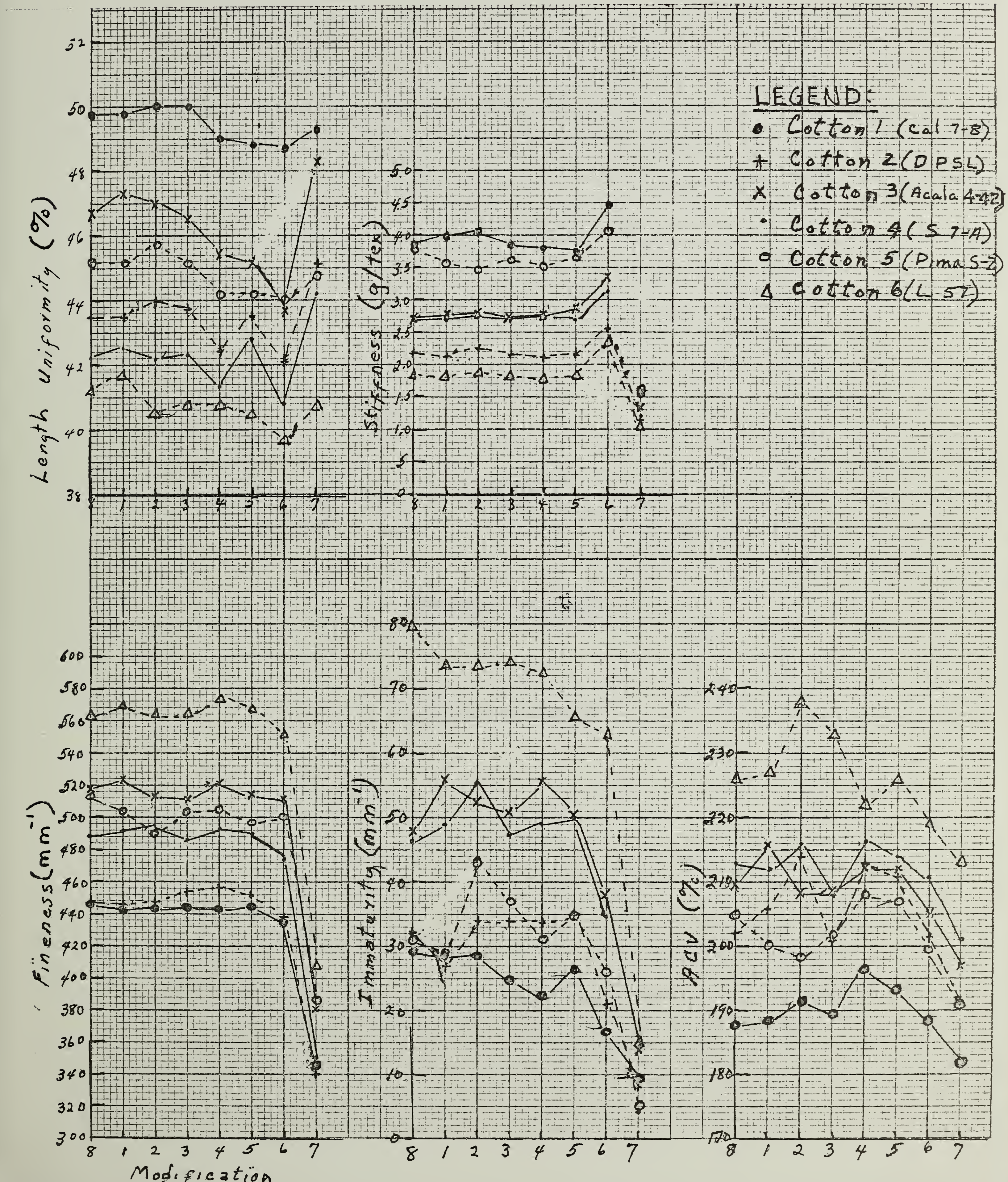


Figure A-2. Variety modification interaction for length uniformity, stiffness, fineness, immaturity and ACV (no mechanical treatment).



SECTION X

APPENDIX B

CRUSHING TREATMENT

(Tables and Graphs)

TABLE B-I. Fiber Property Means for Each Variety on the Crushed Samples and the Significance at the 5 Per Cent Level[1]

Variety	Tenacity 1/8 in. Gauge g/tex		Elongation %		Toughness g/tex		Impact Strength g/tex		50% Span Length in.	
Cal 7-8	20.79	B	8.58	D	0.918	C	19.53	B	0.501	B
DP-SL	18.67	D	11.17	A	1.047	B	17.28	D	0.491	C
A 4-42	20.33	C	10.12	B	1.054	B	18.64	C	0.495	BC
St. 7A	17.90	E	9.15	C	0.830	D	16.12	E	0.480	D
P S-2	27.32	A	10.26	B	1.405	A	25.96	A	0.570	A
L-57	16.33	F	11.37	A	0.939	C	15.19	F	0.397	E

Variety	2.5% Span Length in.		Fineness mm^{-1}		Immaturity mm^{-1}		ACV %	
Cal 7-8	1.029	D	423.2	E	18.8	F	193.5	E
DP-SL	1.108	B	426.8	D	25.2	E	208.7	C
A 4-42	1.070	C	481.7	B	41.5	B	211.4	B
St. 7A	1.107	B	456.9	C	36.6	C	214.0	B
P S-2	1.281	A	483.0	B	28.4	D	205.6	D
L-57	0.955	E	514.7	A	53.3	A	227.0	A

[1] These are the means within a variety for all of the modifications, crushing levels and humidities combined.

TABLE B-II. Effect of Modification, Crushing Level, and Crushing Humidity on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(a) Tenacity 1/8 in. Gauge (g/tex)

Modification	Variety: Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57		All Varieties	
Control	20.23	B	18.69	B	19.90	BC	17.42	BC	27.47	BC	16.40	B	20.02	B
35%-72°C	20.52	B	18.61	B	19.87	BC	17.99	B	27.27	BC	16.27	BC	20.09	B
65%-72°C	20.42	B	18.72	B	20.05	B	17.74	BC	27.06	C	15.84	CD	19.97	B
80%-72°C	20.45	B	18.63	B	19.75	BC	17.62	BC	27.79	B	15.92	BCD	20.03	B
35%-180°C	19.69	B	18.33	B	19.44	C	17.32	BC	26.23	D	15.79	CD	19.47	C
65%-180°C	19.50	B	18.10	B	19.37	C	17.15	C	27.00	C	15.60	D	19.45	C
Alcohol	19.86	B	18.40	B	19.81	BC	17.85	BC	27.15	C	16.28	BC	19.90	B
NaOH	25.64	A	19.91	A	24.42	A	20.15	A	28.61	A	18.51	A	22.88	A
Crushing level (psi)														
No crushing	22.42	A	19.72	A	21.37	A	18.57	A	29.03	A	17.20	A	21.38	A
17,000	21.26	B	18.81	B	20.53	B	18.09	B	27.50	B	16.52	B	20.45	B
50,000	20.05	C	18.33	C	19.93	C	17.74	C	26.69	C	15.94	C	19.78	C
150,000	19.42	D	17.84	D	19.48	D	17.22	D	26.07	D	15.65	D	19.28	D
Crushing humidity														
35%	20.38	B	18.34	B	19.85	C	17.58	B	26.76	B	16.00	B	19.82	C
65%	20.93	A	18.84	A	20.40	B	18.04	A	27.67	A	16.41	A	20.38	B
80%	21.06	A	18.84	A	20.73	A	18.09	A	27.54	A	16.57	A	20.47	A

TABLE B-II. Effect of Modification, Crushing Level, and Crushing Humidity on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(b) Elongation (%)

Modification	Variety: Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	All Varieties
Control	7.37 B	10.02 B	8.94 B	8.23 B	9.20 B	10.22 B	9.00 B
35%-72°C	7.40 B	10.39 B	8.97 B	8.07 B	9.42 B	10.51 B	9.13 B
65%-72°C	7.42 B	10.12 B	9.04 B	8.15 B	9.38 B	10.60 B	9.12 B
80%-72°C	7.42 B	10.16 B	9.05 B	8.10 B	9.08 B	10.71 B	9.09 B
35%-180°C	7.31 B	10.16 B	8.73 B	7.89 BC	9.04 B	10.38 B	8.92 B
65%-180°C	7.19 B	10.07 B	8.72 B	7.95 BC	8.90 B	10.49 B	8.89 B
Alcohol	6.63 B	9.48 B	7.99 C	7.55 C	8.27 B	9.15 C	8.18 C
NaOH	17.87 A	18.95 A	19.56 A	17.28 A	18.76 A	18.93 A	18.56 A
Crushing level (psi)							
No crushing	6.97 C	10.02 C	8.69 C	7.85 C	9.22 B	10.07 C	8.80 D
17,000	8.82 B	11.42 B	10.44 B	9.39 B	10.55 A	11.59 B	10.37 C
50,000	9.18 A	11.45 B	10.70 A	9.62 A	10.57 A	11.91 A	10.59 B
150,000	9.34 A	11.70 A	10.67 A	9.74 A	10.68 A	11.93 A	10.68 A
Crushing humidity							
35%	8.38 B	10.97 B	9.95 B	9.04 B	10.09 B	11.17 B	9.93 C
65%	8.64 A	11.20 A	10.21 A	9.16 A	10.29 A	11.44 A	10.16 B
80%	8.72 A	11.33 A	10.22 A	9.25 A	10.39 A	11.52 A	10.24 A

TABLE B-II. Effect of Modification, Crushing Level, and Crushing Humidity on Fiber Properties with the Relative Significance as Tested by the Duncan's Mulitple Range Test at the 5 Per Cent Level

(c) Toughness (g/tex)

Modification	Variety						All Varieties
	Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	
Control	0.739 B	0.933 BC	0.887 B	0.715 BC	1.257 B	0.838 B	0.895 B
35%-72°C	0.751 B	0.963 B	0.890 B	0.724 B	1.278 B	0.854 B	0.910 B
65%-72°C	0.751 B	0.947 BC	0.904 B	0.720 B	1.264 B	0.837 B	0.904 B
80%-72°C	0.754 B	0.944 BC	0.894 B	0.710 BC	1.257 B	0.849 B	0.901 B
35%-180°C	0.714 BC	0.930 BC	0.847 B	0.681 CD	1.184 B	0.818 B	0.862 C
65%-180°C	0.695 BC	0.909 BC	0.842 B	0.681 CD	1.200 B	0.816 B	0.857 C
Alcohol	0.650 C	0.868 C	0.783 C	0.670 D	1.114 B	0.741 C	0.804 D
NaOH	2.290 A	1.884 A	2.387 A	1.740 A	2.684 A	1.756 A	2.123 A
Crushing level (psi)							
No crushing	0.810 C	0.990 C	0.953 B	0.740 B	1.337 C	0.876 B	0.951 D
17,000	0.967 A	1.078 A	1.095 A	0.861 A	1.456 A	0.967 A	1.071 A
50,000	0.952 AB	1.067 AB	1.094 A	0.866 A	1.419 B	0.961 A	1.060 B
150,000	0.943 B	1.054 B	1.075 A	0.853 A	1.407 B	0.952 A	1.047 C
Crushing humidity							
35%	0.881 B	1.012 B	1.015 B	0.807 C	1.358 B	0.905 B	0.997 C
65%	0.930 A	1.058 A	1.065 A	0.837 B	1.425 A	0.948 A	1.044 B
80%	0.943 A	1.071 A	1.082 A	0.847 A	1.432 A	0.962 A	1.056 A

TABLE B–II. Effect of Modification, Crushing Level, and Crushing Humidity on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(d) Impact Strength (g/tex)

Modification	Variety: Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57		All Varieties	
Control	18.81	B	16.90	B	17.98	B	15.62	B	25.82	B	14.90	B	18.34	B
35%-72°C	18.86	B	16.89	B	17.85	B	15.92	B	25.85	B	14.95	B	18.39	B
65%-72°C	18.67	B	17.21	B	17.97	B	15.44	B	25.76	B	14.83	B	18.31	B
80%-72°C	18.81	B	17.22	B	17.96	B	15.50	B	26.01	B	14.85	B	18.39	B
35%-180°C	17.97	B	16.56	B	17.22	B	15.12	B	24.50	B	14.55	B	17.65	D
65%-180°C	17.72	B	16.22	B	17.23	B	15.24	B	25.16	B	14.49	B	17.68	D
Alcohol	18.37	B	16.66	B	17.69	B	15.57	B	24.94	B	14.41	B	17.94	C
NaOH	27.01	A	20.58	A	25.22	A	20.59	A	29.66	A	18.55	A	23.60	A
Crushing level (psi)														
No crushing	20.07	A	17.66	A	18.93	A	15.95	B	27.01	A	15.48	A	19.18	A
17,000	19.96	A	17.59	A	19.07	A	16.42	A	26.47	B	15.57	A	19.18	A
50,000	19.35	B	17.23	B	18.55	B	16.32	A	25.56	C	15.08	B	18.68	B
150,000	18.73	C	16.64	C	18.01	C	15.81	B	24.81	D	14.63	C	18.10	C
Crushing humidity														
35%	18.92	C	16.90	B	18.07	C	15.68	B	25.19	B	14.79	C	18.26	C
65%	19.69	B	17.41	A	18.83	B	16.28	A	26.26	A	15.28	B	18.96	B
80%	19.98	A	17.54	A	19.03	A	16.41	A	26.43	A	15.51	A	19.15	A

TABLE B-II. Effect of Modification, Crushing Level, and Crushing Humidity on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(e) 50 Per Cent Span Length (in.)

Modification-	Variety: Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57		All Varieties	
Control	0.521	A	0.502	A	0.515	A	0.501	A	0.593	AB	0.402	D	0.506	A
35%-72°C	0.517	A	0.507	A	0.514	A	0.503	A	0.591	AB	0.409	A	0.507	A
65%-72°C	0.519	A	0.505	A	0.513	AB	0.486	A	0.590	AB	0.407	B	0.503	AB
80%-72°C	0.521	A	0.508	A	0.514	A	0.490	A	0.595	A	0.409	A	0.506	A
35%-180°C	0.508	A	0.494	A	0.497	B	0.485	A	0.577	B	0.401	E	0.494	BC
65%-180°C	0.503	A	0.490	A	0.497	B	0.482	A	0.578	B	0.403	C	0.492	C
Alcohol	0.458	B	0.462	B	0.450	C	0.447	B	0.525	C	0.366	G	0.451	D
NaOH	0.456	B	0.459	B	0.461	C	0.443	B	0.513	C	0.382	F	0.452	D
Crushing level (psi)														
No crushing	0.519	A	0.485	C	0.502	B	0.472	C	0.583	A	0.392	C	0.492	B
17,000	0.518	A	0.502	A	0.509	A	0.495	A	0.588	A	0.406	A	0.503	A
50,000	0.492	B	0.494	B	0.491	C	0.485	B	0.564	B	0.401	B	0.488	C
150,000	0.473	C	0.482	D	0.478	D	0.468	D	0.546	C	0.390	D	0.473	D
Crushing humidity														
35%	0.485	C	0.480	C	0.480	C	0.470	C	0.555	C	0.389	C	0.476	C
65%	0.504	B	0.495	B	0.500	B	0.484	B	0.576	B	0.401	B	0.493	B
80%	0.512	A	0.498	A	0.505	A	0.485	A	0.580	A	0.402	A	0.497	A

TABLE B-II. Effect of Modification, Crushing Level, and Crushing Humidity on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(f) 2.5 Per Cent Span Length (in.)

Modification	Variety: Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	All Varieties
Control	1.055 A	1.135 AB	1.098 A	1.138 A	1.318 A	0.971 A	1.119 A
35%-72°C	1.051 A	1.139 A	1.097 AB	1.141 A	1.314 A	0.979 A	1.120 A
65%-72°C	1.052 A	1.134 AB	1.096 AB	1.133 A	1.311 A	0.982 A	1.118 A
80%-72°C	1.055 A	1.138 A	1.098 A	1.132 A	1.317 A	0.981 A	1.120 A
35%-180°C	1.047 A	1.129 AB	1.090 AB	1.124 A	1.302 A	0.974 A	1.111 AB
65%-180°C	1.042 A	1.115 B	1.086 B	1.122 A	1.302 A	0.972 A	1.107 B
Alcohol	1.004 B	1.084 C	1.042 C	1.084 B	1.240 B	0.920 B	1.062 C
NaOH	0.922 C	0.990 D	0.956 D	0.984 C	1.144 C	0.864 C	0.977 D
Crushing level (psi)							
No crushing	1.051 A	1.114 B	1.085 A	1.115 B	1.302 A	0.958 B	1.104 A
17,000	1.042 B	1.120 A	1.082 B	1.119 A	1.295 A	0.967 A	1.104 A
50,000	1.018 C	1.107 C	1.064 C	1.105 C	1.273 B	0.955 C	1.087 B
150,000	1.003 D	1.092 D	1.051 D	1.090 D	1.254 C	0.941 D	1.072 C
Crushing humidity							
35%	1.016 C	1.097 C	1.056 C	1.095 C	1.266 B	0.943 C	1.079 C
65%	1.032 B	1.112 B	1.075 B	1.112 B	1.285 A	0.959 B	1.096 B
80%	1.038 A	1.115 A	1.080 A	1.115 A	1.292 A	0.963 A	1.101 A

TABLE B-II. Effect of Modification, Crushing Level, and Crushing Humidity on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(g) Fineness (mm^{-1})

Modification	Variety: Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	All Varieties
Control	436.4 A	437.2 AB	497.2 A	473.0 AB	501.0 A	533.7 A	479.7 A
35%-72°C	434.6 A	438.3 AB	497.7 A	476.0 A	495.5 AB	533.7 A	479.3 A
65%-72°C	434.5 A	438.6 AB	497.3 A	473.9 AB	493.7 AB	531.7 A	478.3 A
80%-72°C	434.2 A	442.6 A	494.5 AB	470.2 B	496.8 AB	532.1 A	478.4 A
35%-180°C	433.5 A	443.0 A	498.3 A	474.4 AB	497.8 AB	537.0 A	480.7 A
65%-180°C	435.9 A	440.8 A	496.0 A	470.0 B	495.8 AB	534.5 A	478.8 A
Alcohol	424.1 B	430.7 B	488.5 B	460.8 C	489.7 B	516.6 B	468.4 B
NaOH	352.2 C	343.5 C	383.7 C	357.0 D	393.8 C	398.2 C	371.4 C
Crushing level (psi)							
No crushing	430.4 A	435.2 A	499.4 A	471.4 A	487.9 A	545.4 A	478.3 A
17,000	421.1 BC	425.0 B	478.2 B	454.7 B	481.6 B	508.9 B	461.6 B
50,000	421.6 B	423.9 BC	474.8 C	451.0 C	480.7 B	503.3 C	459.2 C
150,000	419.6 C	423.2 C	474.2 C	450.5 C	481.9 B	501.1 C	458.4 C
Crushing humidity							
35%	424.2 A	428.0 A	484.0 A	458.8 A	482.0 A	517.7 A	465.8 A
65%	423.0 AB	426.8 AB	481.5 B	456.7 B	483.8 A	513.8 B	464.1 B
80%	422.3 B	425.7 B	479.5 C	455.2 B	483.2 A	512.5 B	463.3 C

TABLE B-II. Effect of Modification, Crushing Level, and Crushing Humidity on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(h) Immaturity (mm^{-1})

Modification	Variety: Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57		All Varieties	
Control	23.3	A	28.7	A	45.9	A	41.4	A	29.6	C	63.5	A	38.7	AB
35%-72°C	23.0	AB	28.6	A	49.2	A	43.9	A	31.3	BC	61.0	AB	39.5	AB
65%-72°C	22.2	ABC	29.5	A	47.6	A	45.3	A	36.0	A	61.2	AB	40.3	A
80%-72°C	20.0	C	29.4	A	47.0	A	41.3	A	34.2	AB	61.0	AB	38.8	AB
35%-180°C	20.6	BC	28.4	A	46.5	A	42.1	A	33.0	ABC	60.4	AB	38.5	B
65%-180°C	21.4	ABC	30.2	A	47.3	A	40.9	A	33.6	AB	58.0	B	38.6	AB
Alcohol	12.2	D	19.5	B	33.8	B	29.7	B	22.1	D	44.8	C	27.0	C
NaOH	7.7	E	7.3	C	14.7	C	8.1	C	7.1	E	16.2	D	10.2	D
Crushing level (psi)														
No crushing	23.2	A	28.1	A	45.7	A	42.0	A	29.7	A	64.6	A	38.9	A
17,000	18.1	B	24.8	B	41.6	B	35.9	B	28.6	AB	51.4	B	33.4	B
50,000	16.8	B	23.9	B	38.5	C	34.8	BC	28.1	AB	49.1	C	31.9	C
150,000	17.2	B	23.9	B	40.2	BC	33.6	C	27.2	B	48.0	C	31.7	C
Crushing humidity														
35%	18.6	A	25.0	A	42.0	A	36.9	A	28.5	A	53.8	A	34.1	A
65%	18.5	A	25.6	A	41.1	A	36.9	A	28.5	A	53.4	A	34.0	A
80%	19.3	A	25.0	A	41.4	A	36.0	A	28.1	A	52.6	A	33.7	A

TABLE B-II. Effect of Modification, Crushing Level, and Crushing Humidity on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(i) Alkali Centrifuge Value (%)

Modification	Variety: Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57		All Varieties	
Control	193.0	B	207.1	BC	212.7	A	214.5	A	205.7	B	228.8	AB	210.3	B
35%-72°C	193.1	B	213.7	AB	213.5	A	216.7	A	204.5	B	229.5	AB	211.8	AB
65%-72°C	193.4	B	212.0	ABC	212.7	A	217.0	A	204.9	B	236.8	A	212.8	AB
80%-72°C	192.2	B	205.0	C	212.8	A	215.0	A	204.7	B	229.9	AB	209.9	B
35%-180°C	199.0	A	215.7	A	214.6	A	217.2	A	212.7	A	227.5	AB	214.4	A
65%-180°C	198.7	A	214.7	A	214.2	A	217.8	A	212.5	A	229.6	AB	214.6	A
Alcohol	195.6	AB	209.3	ABC	211.6	A	213.2	A	206.8	B	222.5	BC	209.8	B
NaOH	183.2	C	192.1	D	199.5	B	200.3	B	193.0	C	212.0	C	196.7	C
Crushing level (psi)														
No crushing	189.7	C	205.1	B	208.5	C	211.4	C	201.4	C	225.7	B	207.0	C
17,000	193.1	B	209.1	A	211.6	B	213.6	B	205.3	B	227.1	AB	210.0	B
50,000	196.1	A	209.7	A	213.2	A	215.8	A	207.6	A	227.9	A	211.7	A
150,000	195.2	A	210.9	A	212.5	A	215.0	AB	208.2	A	227.6	AB	211.6	A
Crushing humidity														
35%	194.8	A	210.5	A	212.7	A	215.2	A	207.0	A	227.9	A	211.3	A
65%	193.4	B	208.3	B	211.4	B	214.0	B	205.8	B	227.6	A	210.0	B
80%	192.4	C	207.3	B	210.3	C	212.8	C	204.0	C	225.8	B	208.8	C

TABLE B-III. Correlation Coefficients of Combinations of Properties on Data From Crushed Samples of Cal 7-8

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.78	-0.83	-0.55	-0.64	-0.13	0.19	0.56	0.16
D	-0.49	-0.25	-0.66	-0.62	0.62	0.76	0.73	
A	-0.86	-0.65	-0.96	-0.96	0.49	0.82		
2.5% SL	-0.52	-0.25	-0.76	-0.71	0.87			
50% SL	-0.12	0.14	-0.40	-0.33				
Tou.	0.92	0.74	0.99					
E_1.	0.85	0.62						
T_1.	0.89							
			(b) Six Modifications[1,2]					
ACV	-0.64	-0.65	0.37	0.11	-0.55	-0.58	-0.26	-0.42
D	0.30	0.48	-0.56	-0.45	0.29	0.38	0.49	
A	0.17	0.52	-0.78	-0.70	0.21	0.39		
2.5% SL	0.72	0.80	-0.45	-0.10	0.89			
50% SL	0.74	0.74	-0.27	0.09				
Tou.	0.16	-0.29	0.90					
E_1.	-0.19	-0.68						
T_1.	0.69							

[1] The total number of paired observations is 192 and 144 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, four crushing levels and three crushing humidities. For 192 and 144 paired values, $r = 0.14$ and 0.16 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE B-IV. Correlation Coefficients of Combinations of Properties on Data From Crushed Samples of Deltapine Smooth Leaf

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.62	-0.57	-0.57	-0.64	0.18	0.45	0.59	0.49
D	-0.54	-0.18	-0.76	-0.75	0.46	0.78	0.84	
A	-0.75	-0.30	-0.95	-0.95	0.40	0.83		
2.5% SL	-0.44	-0.03	-0.76	-0.73	0.79			
50% SL	-0.04	0.18	-0.29	-0.25				
Tou.	0.79	0.43	0.98					
E_1.	0.70	0.26						
T_1.	0.70							
			(b) Six Modifications[1,2]					
ACV	-0.22	-0.41	0.20	-0.04	-0.12	-0.24	-0.22	-0.11
D	0.16	0.25	-0.39	-0.28	-0.11	0.06	0.48	
A	0.04	0.42	-0.66	-0.46	-0.23	0.02		
2.5% SL	0.57	0.50	0.14	0.48	0.81			
50% SL	0.42	0.26	0.39	0.60				
Tou.	0.24	0.14	0.82					
E_1.	-0.13	-0.45						
T_1.	0.58							

[1] The total number of paired observations is 192 and 144 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, four crushing levels and three crushing humidities. For 192 and 144 paired values, r = 0.14 and 0.16 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE B-V. Correlation Coefficients of Combinations of Properties on Data From Crushed Samples of Acala 4-42

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.78	-0.83	-0.68	-0.74	0.16	0.51	0.68	0.62
D	-0.73	-0.59	-0.82	-0.82	0.54	0.83	0.88	
A	-0.84	-0.66	-0.97	-0.95	0.40	0.82		
2.5% SL	-0.57	-0.40	-0.76	-0.74	0.79			
50% SL	-0.09	0.00	-0.30	-0.27				
Tou.	0.91	0.80	0.99					
E_1.	0.87	0.71						
T_1.	0.90							
			(b) Six Modifications[1,2]					
ACV	-0.25	-0.45	0.34	0.18	-0.37	-0.38	-0.21	-0.22
D	0.07	0.32	-0.51	-0.41	0.17	0.24	0.50	
A	0.03	0.52	-0.85	-0.71	0.08	0.26		
2.5% SL	0.57	0.64	-0.17	0.10	0.85			
50% SL	0.51	0.42	-0.03	0.15				
Tou.	0.37	-0.03	0.91					
E_1.	0.12	-0.43						
T_1.	0.56							

[1] The total number of paired observations is 192 and 144 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, four crushing levels and three crushing humidities. For 192 and 144 paired values, $r = 0.14$ and 0.16 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE B-VI. Correlation Coefficients of Combinations of Properties on Data From Crushed Samples of Stoneville 7A

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.69	-0.66	-0.67	-0.70	0.39	0.63	0.68	0.62
D	-0.75	-0.49	-0.84	-0.84	0.47	0.80	0.90	
A	-0.86	-0.57	-0.97	-0.97	0.40	0.82		
2.5% SL	-0.61	-0.36	-0.79	-0.77	0.80			
50% SL	-0.17	-0.08	-0.34	-0.32				
Tou.	0.91	0.67	0.99					
E_1.	0.86	0.56						
T_1.	0.81							
			(b) Six Modifications[1,2]					
ACV	-0.31	-0.44	0.33	0.18	0.14	0.05	-0.31	-0.15
D	-0.22	0.30	-0.59	-0.54	-0.11	0.17	0.61	
A	-0.15	0.51	-0.81	-0.70	-0.21	0.10		
2.5% SL	0.25	0.37	-0.16	-0.01	0.76			
50% SL	0.39	0.18	0.24	0.35				
Tou.	0.49	-0.08	0.92					
E_1.	0.24	-0.46						
T_1.	0.48							

[1] The total number of paired observations is 192 and 144 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, four crushing levels and three crushing humidities. For 192 and 144 paired values, r = 0.14 and 0.16 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE B-VII. Correlation Coefficients of Combinations of Properties on Data From Crushed Samples on Pima S-2

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.74	-0.58	-0.62	-0.69	0.04	0.32	0.66	0.50
D	-0.42	-0.12	-0.75	-0.74	0.61	0.76	0.78	
A	-0.60	-0.19	-0.95	-0.95	0.52	0.79		
2.5% SL	-0.14	0.19	-0.73	-0.67	0.88			
50% SL	0.12	0.34	-0.44	-0.37				
Tou.	0.67	0.29	0.99					
E_1.	0.57	0.14						
T_1.	0.75							
			(b) Six Modifications[1,2]					
ACV	-0.59	-0.57	0.15	-0.26	-0.58	-0.62	0.01	-0.10
D	0.03	0.11	-0.08	0.01	0.18	0.10	-0.20	
A	0.15	0.36	-0.40	-0.23	0.07	0.24		
2.5% SL	0.70	0.66	-0.21	0.28	0.85			
50% SL	0.62	0.52	0.01	0.45				
Tou.	0.26	0.01	0.77					
E_1.	-0.30	-0.63						
T_1.	0.80							

[1] The total number of paired observations is 192 and 144 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, four crushing levels and three crushing humidities. For 192 and 144 paired values, r = 0.14 and 0.16 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE B-VIII. Correlations Coefficients of Combinations of Properties on Data From Crushed Samples of Lankart 57

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.51	-0.50	-0.55	-0.60	0.31	0.53	0.54	0.57
D	-0.58	-0.34	-0.82	-0.80	0.36	0.77	0.92	
A	-0.70	-0.41	-0.93	-0.91	0.26	0.75		
2.5% SL	-0.38	-0.28	-0.64	-0.64	0.77			
50% SL	0.08	-0.05	-0.11	-0.12				
Tou.	0.83	0.64	0.98					
E_1.	0.76	0.48						
T_1.	0.75							
			(b) Six Modifications[1,2]					
ACV	-0.03	0.01	0.04	0.04	0.03	0.01	-0.06	-0.10
D	0.22	0.39	-0.75	-0.57	-0.09	0.08	0.74	
A	0.11	0.43	-0.81	-0.60	-0.21	0.05		
2.5% SL	0.65	0.31	0.02	0.21	0.78			
50% SL	0.56	0.12	0.23	0.31				
Tou.	0.14	0.20	0.83					
E_1.	-0.14	-0.37						
T_1.	0.48							

[1]The total number of paired observations is 192 and 144 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, four crushing levels and three crushing humidities. For 192 and 144 paired values, $r = 0.14$ and 0.16 respectively are significant at the 0.05 level.

[2]Alcohol and NaOH modifications are omitted.

TABLE B-IX. Correlation Coefficients of Combinations of Properties on Data From Crushed Samples of Six Varieties Combined

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.56	-0.55	-0.18	-0.40	-0.41	-0.12	0.67	0.74
D	-0.49	-0.40	-0.41	-0.52	-0.19	-0.00	0.87	
A	-0.30	-0.16	-0.58	-0.56	-0.01	0.24		
2.5% SL	0.49	0.63	-0.37	-0.05	0.87			
50% SL	0.59	0.69	-0.27	0.06				
Tou.	0.71	0.56	0.89					
E_1.	0.35	0.15						
T_1.	0.95							
			(b) Six Modifications[1,2]					
ACV	-0.24	-0.25	0.28	-0.03	-0.32	-0.18	0.31	0.34
D	-0.39	-0.37	0.22	-0.18	-0.56	-0.36	0.84	
A	-0.01	-0.00	0.21	0.14	-0.33	-0.10		
2.5% SL	0.83	0.85	-0.09	0.70	0.86			
50% SL	0.83	0.84	-0.27	0.56				
Tou.	0.77	0.71	0.51					
E_1.	-0.12	-0.24						
T_1.	0.97							

[1]The total number of paired observations is 1152 and 836 for eight and six modifications respectively with four sets of subgroups consisting of six varieties, eight or six modifications, four crushing levels and three crushing humidities. For 1152 and 836 paired values, $r = 0.06$ and $r = 0.07$ respectively are significant at the 0.05 level.

[2]Alcohol and NaOH modifications are omitted.

Figure B-1. Crushing level-humidity interactions for toughness, elongation tenacity and impact strength on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42 (with 8 modifications.

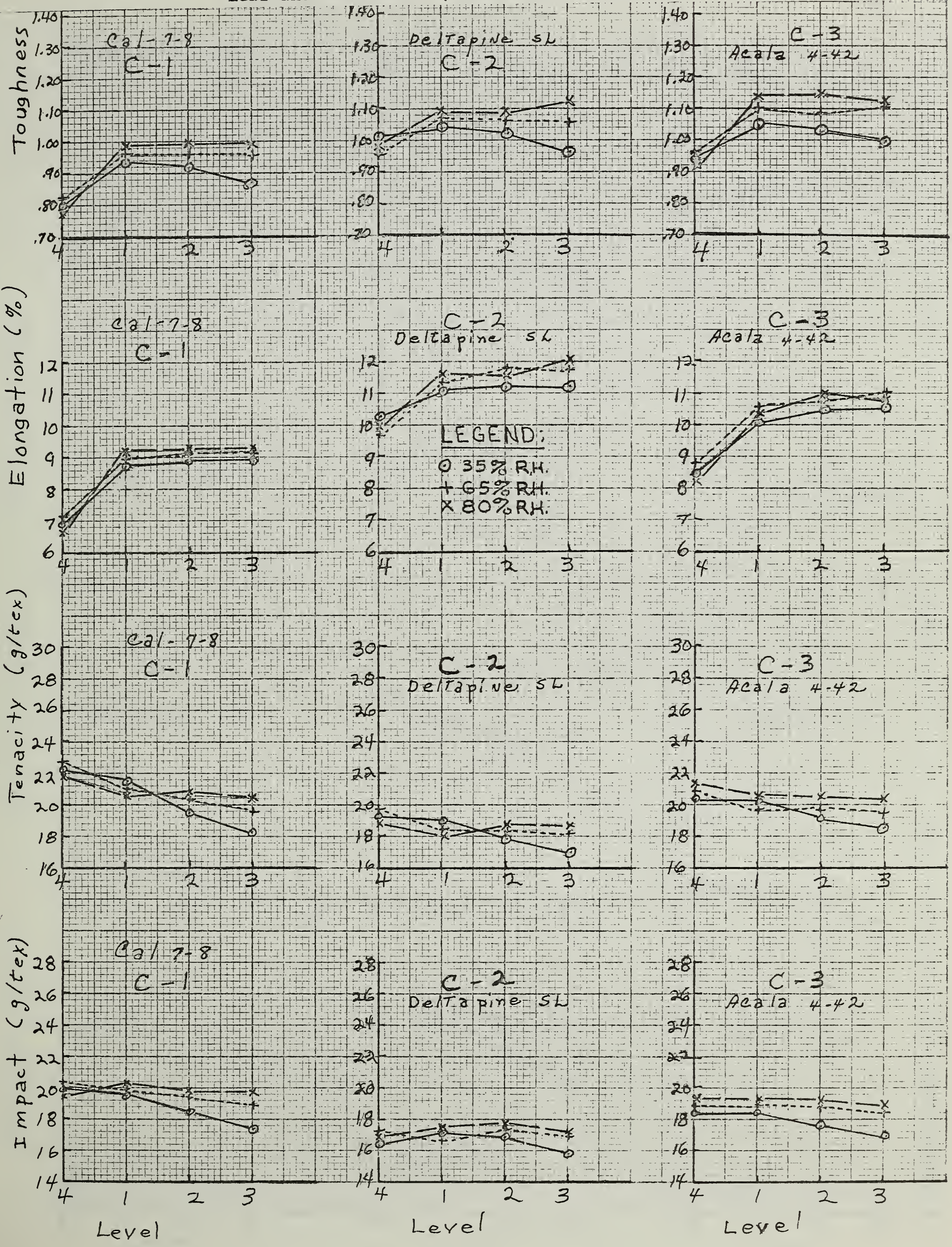


Figure B-2. Crushing level-humidity interactions for toughness, elongation, tenacity and impact strength on Stoneville 7A, Pima S-2 and Lankart-57 (8 modifications).

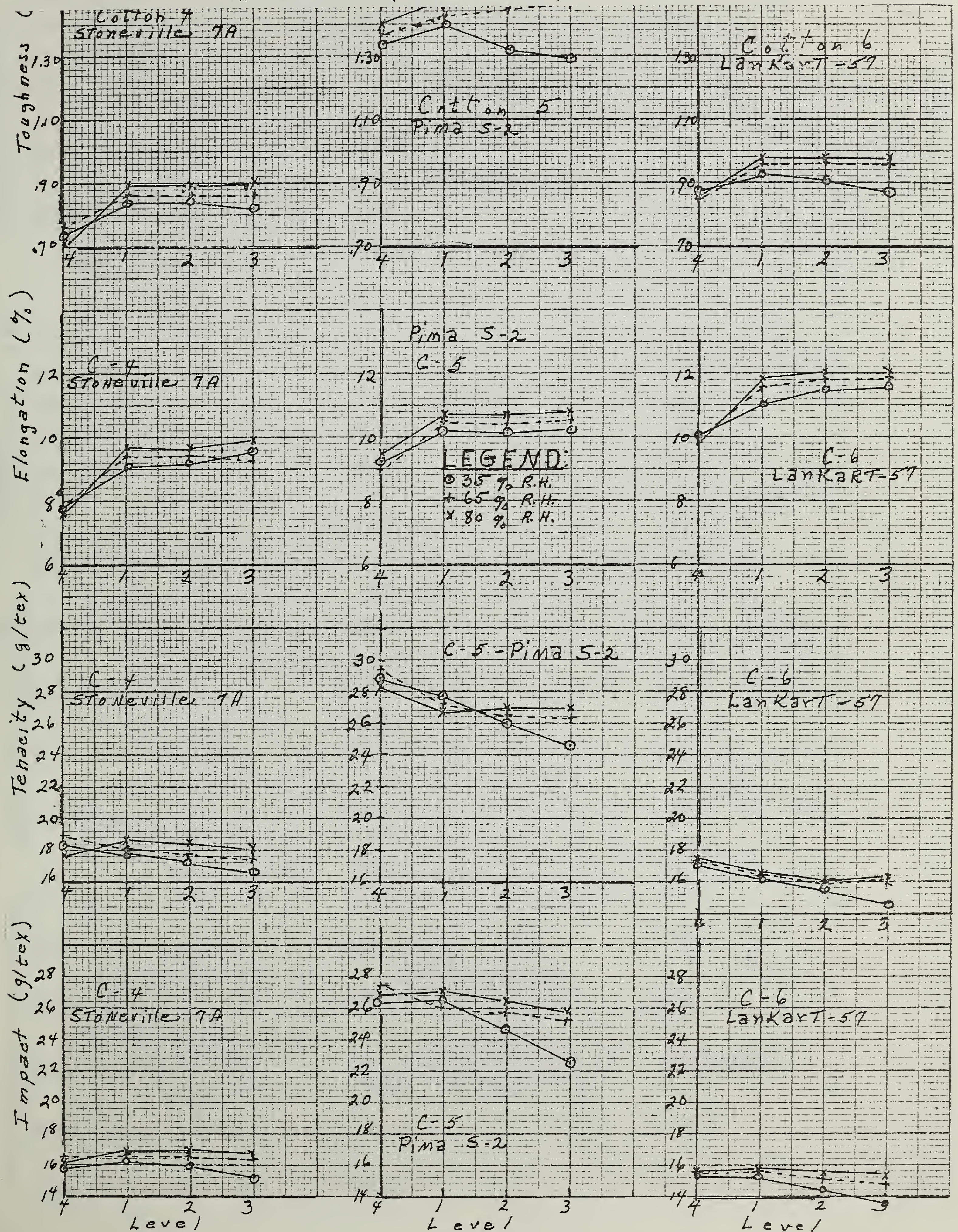


Figure B-3. Crushing level-humidity interactions for stiffness, length uniformity, 2.5% span length, 50% span length on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42 (8 modifications).

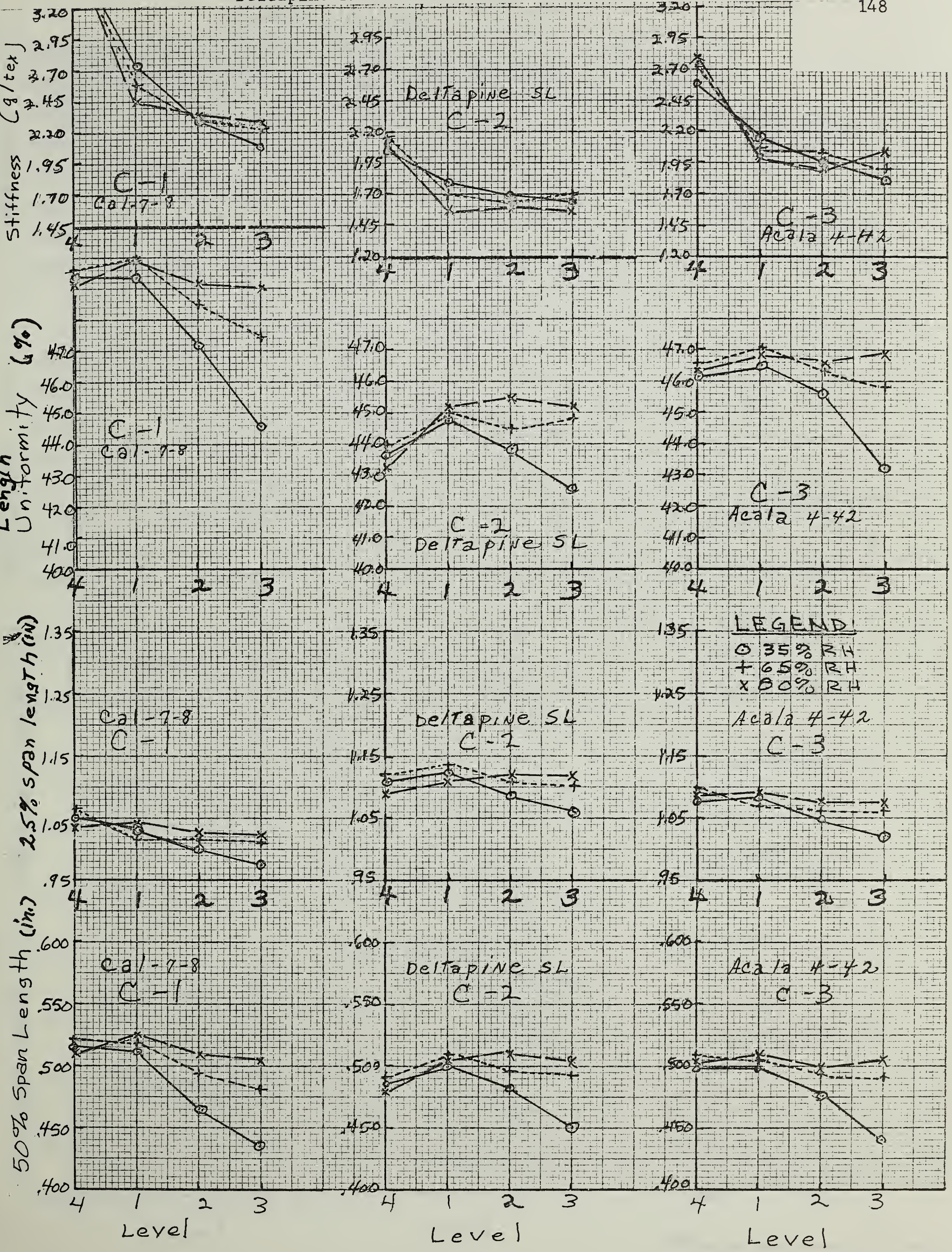


Figure B-4. Crushing level-humidity interactions for stiffness, length uniformity, 2.5% span length and 50% span length on Stoneville 7A, Pima S-2 and Lankart 57 (8 modifications).

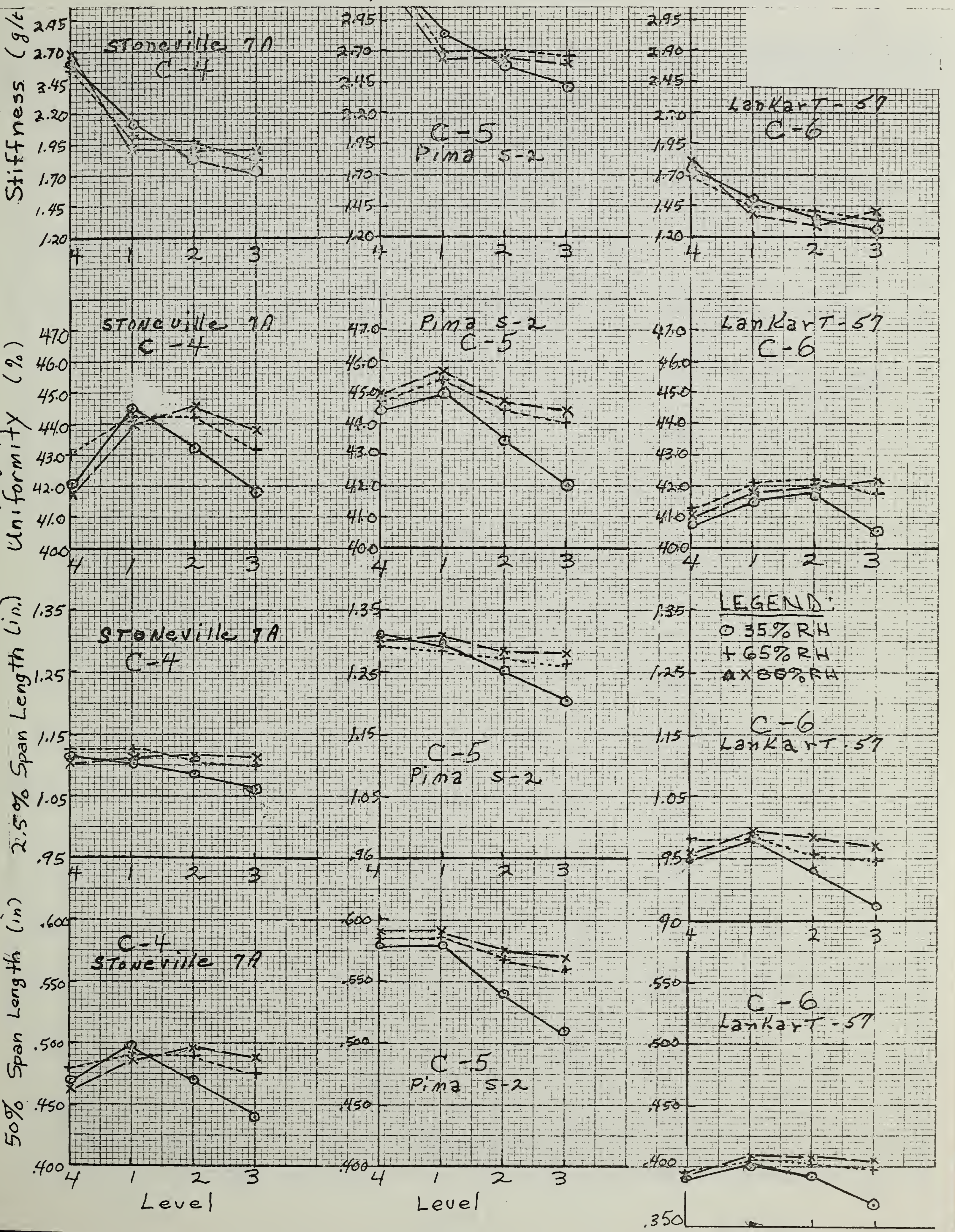


Figure B-5. Crushing level-humidity interactions for ACV, immaturity and fineness on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42 (8 modifications).

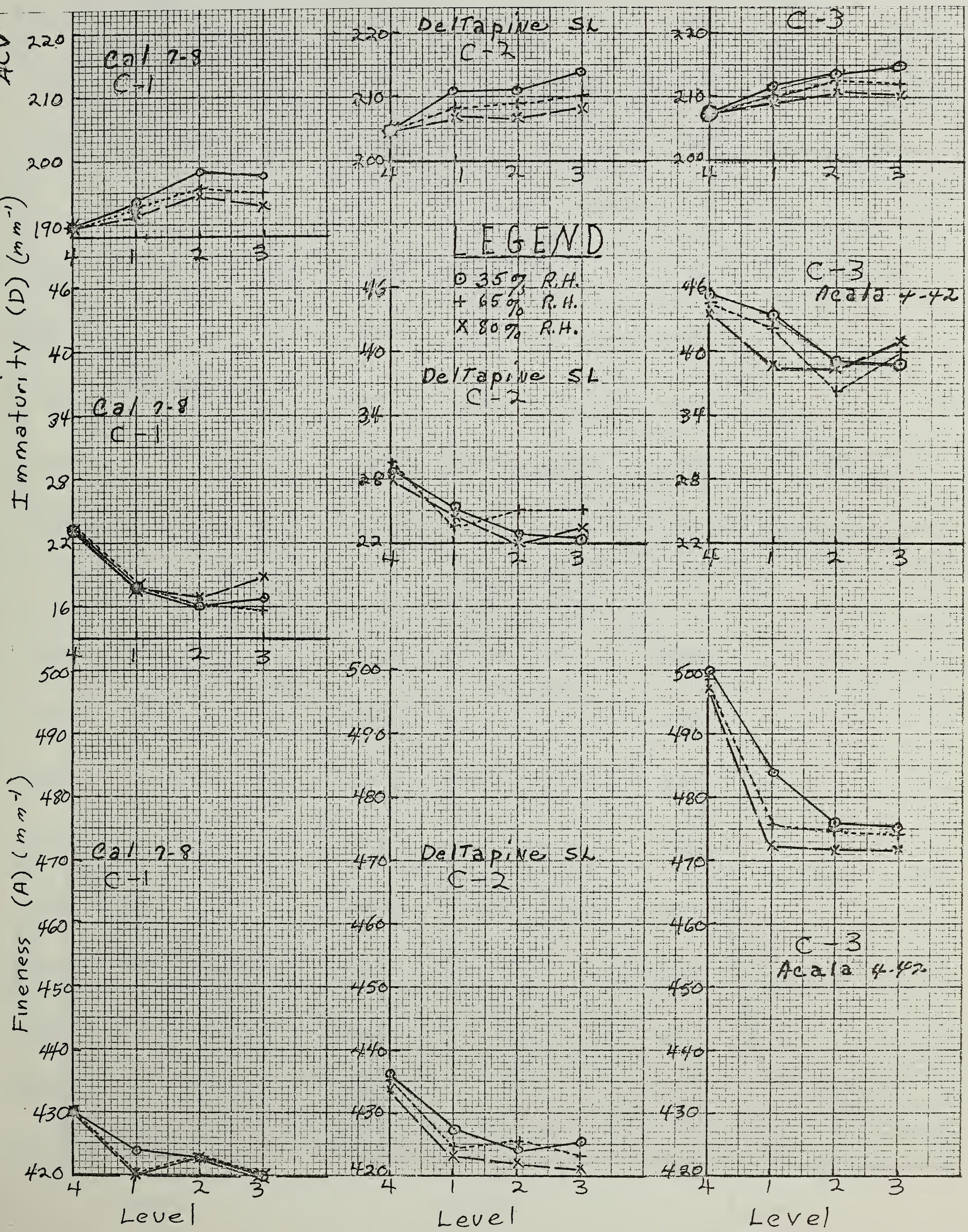


Figure B-6. Crushing level-humidity interactions for ACV, immaturity and fineness on Stoneville 7A, Pima S-2 and Lankart 57 (8 modifications).

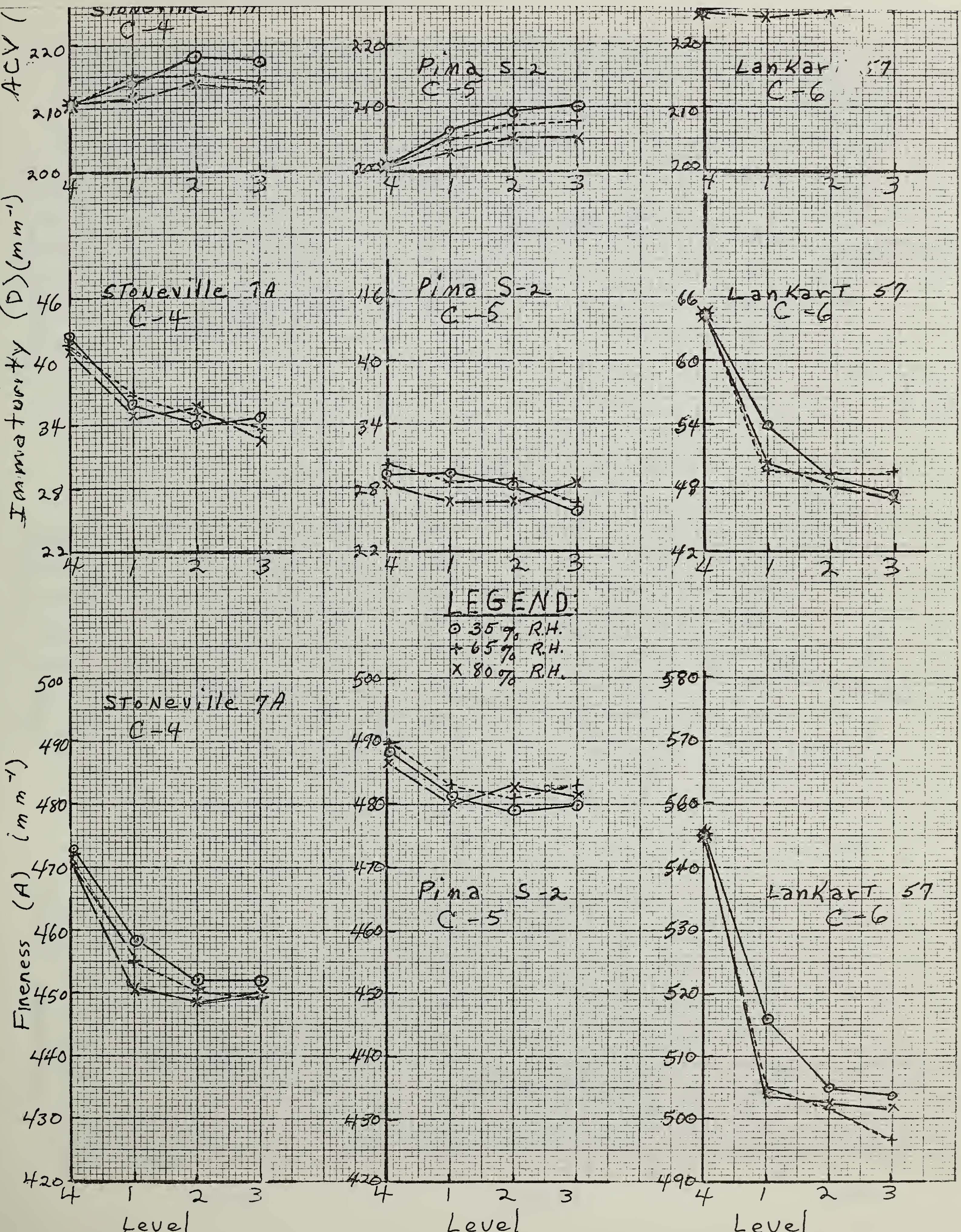
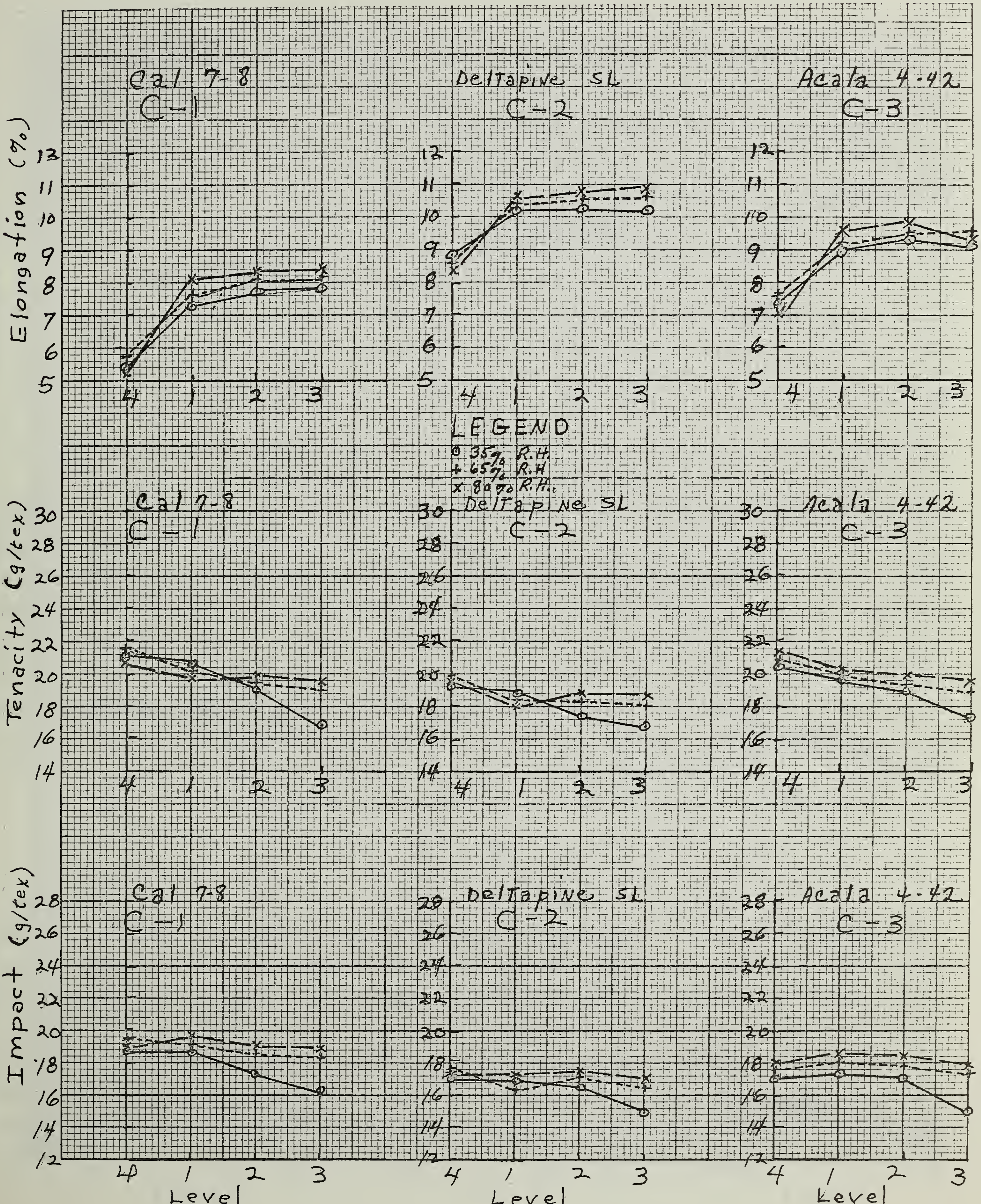


Figure B-7. Crushing level-humidity interactions for elongation, tenacity and impact on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42 (6 modifications).



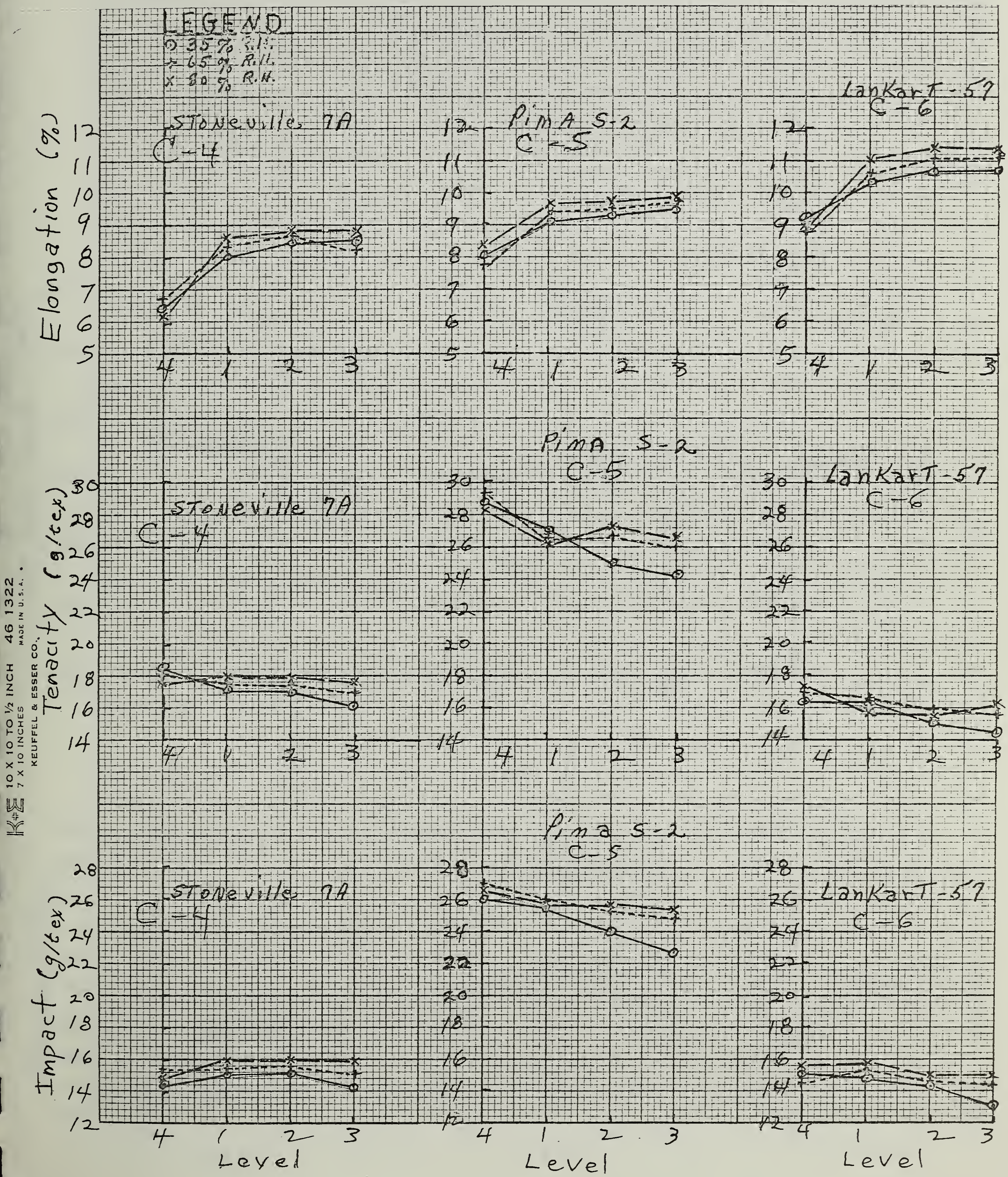


Figure B-8. Crushing level-humidity interactions for elongation, tenacity and impact on Stoneville 7A, Pima S-2 and Lankart 57 (6 modifications).

Figure B-9. Crushing level-humidity interactions for 50% span length and toughness on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42 (6 modifications).

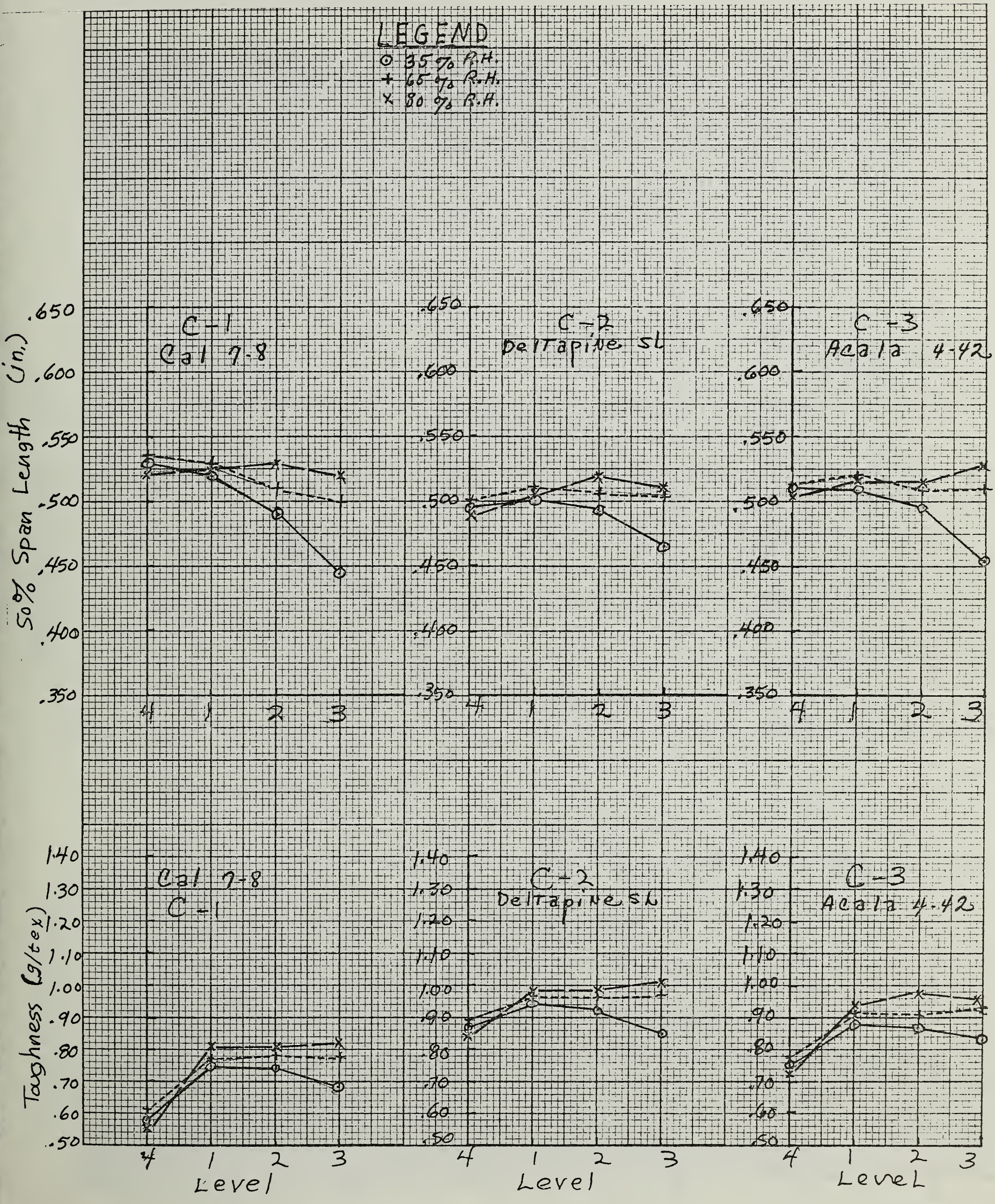


Figure B-10. Crushing level-humidity interactions for 50% span length and toughness on Stoneville 7A, Pima S-2 and Lankart 57 (6 modifications).

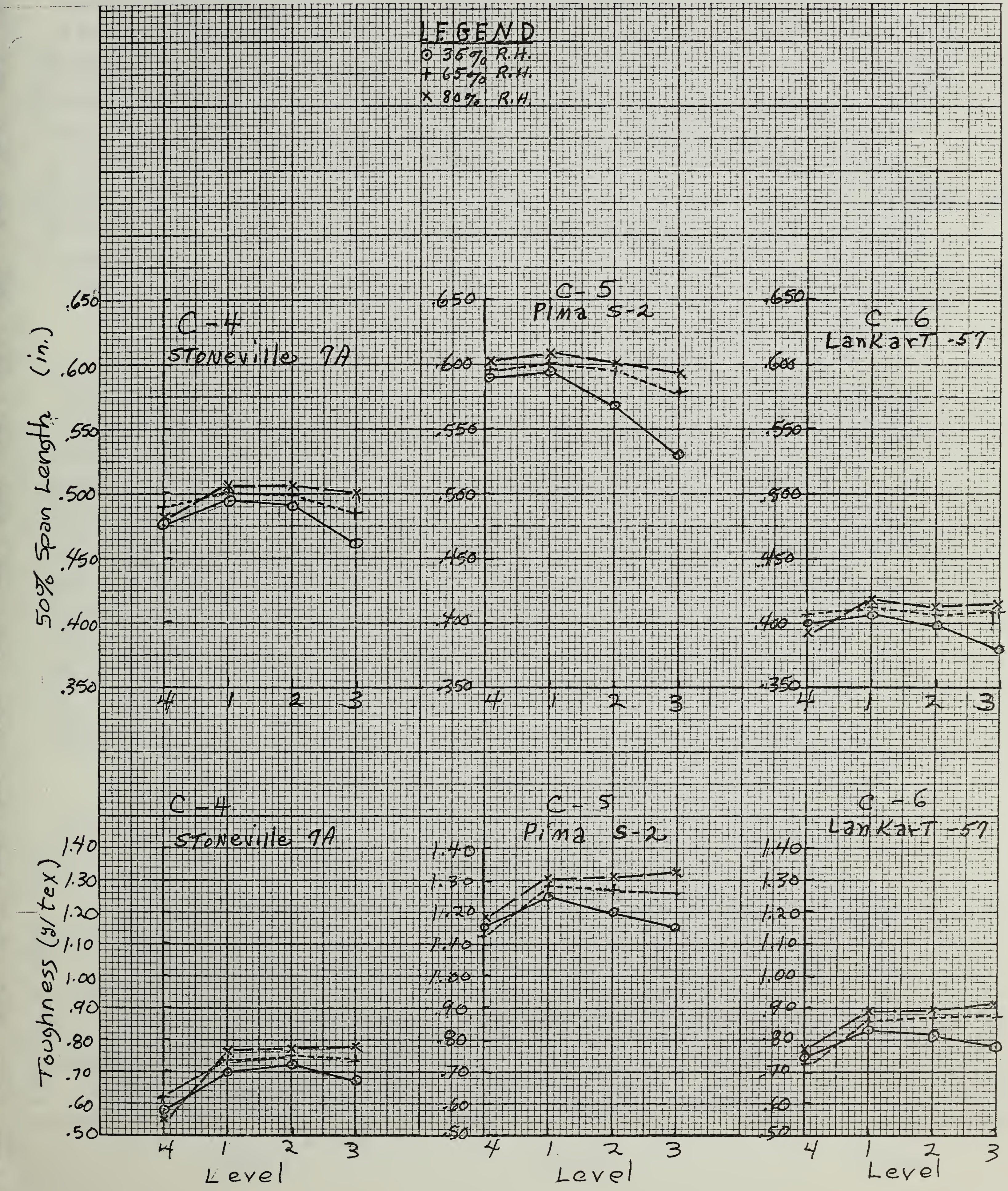


Figure B-11. Crushing level-humidity interactions for stiffness, length uniformity and 2.5% span length on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42 (6 modifications).

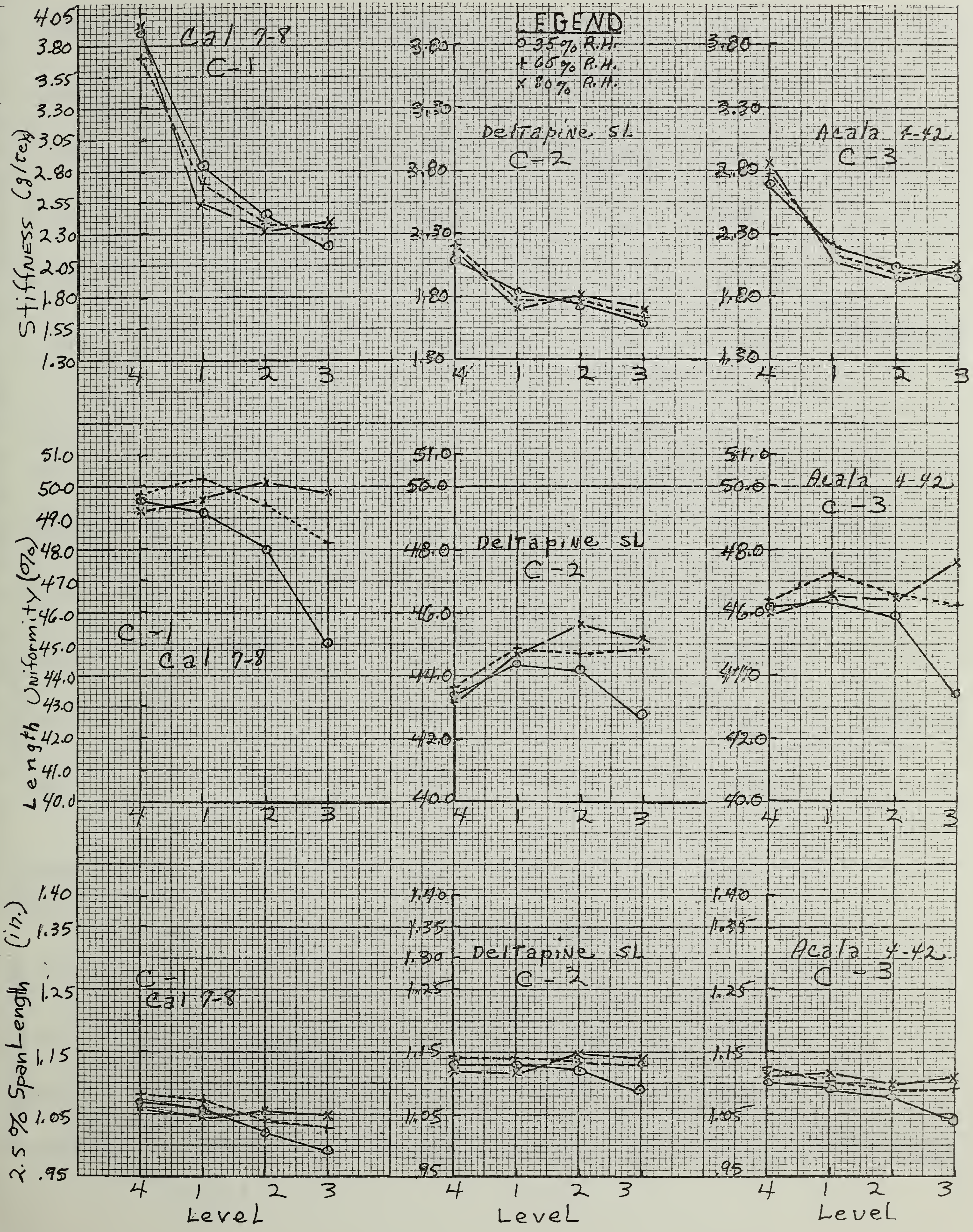


Figure B-12. Crushing level-humidity interactions for stiffness, length uniformity and 2.5% span length on Stoneville 7A, Pima S-2 and Lankart 57 (6 modifications).

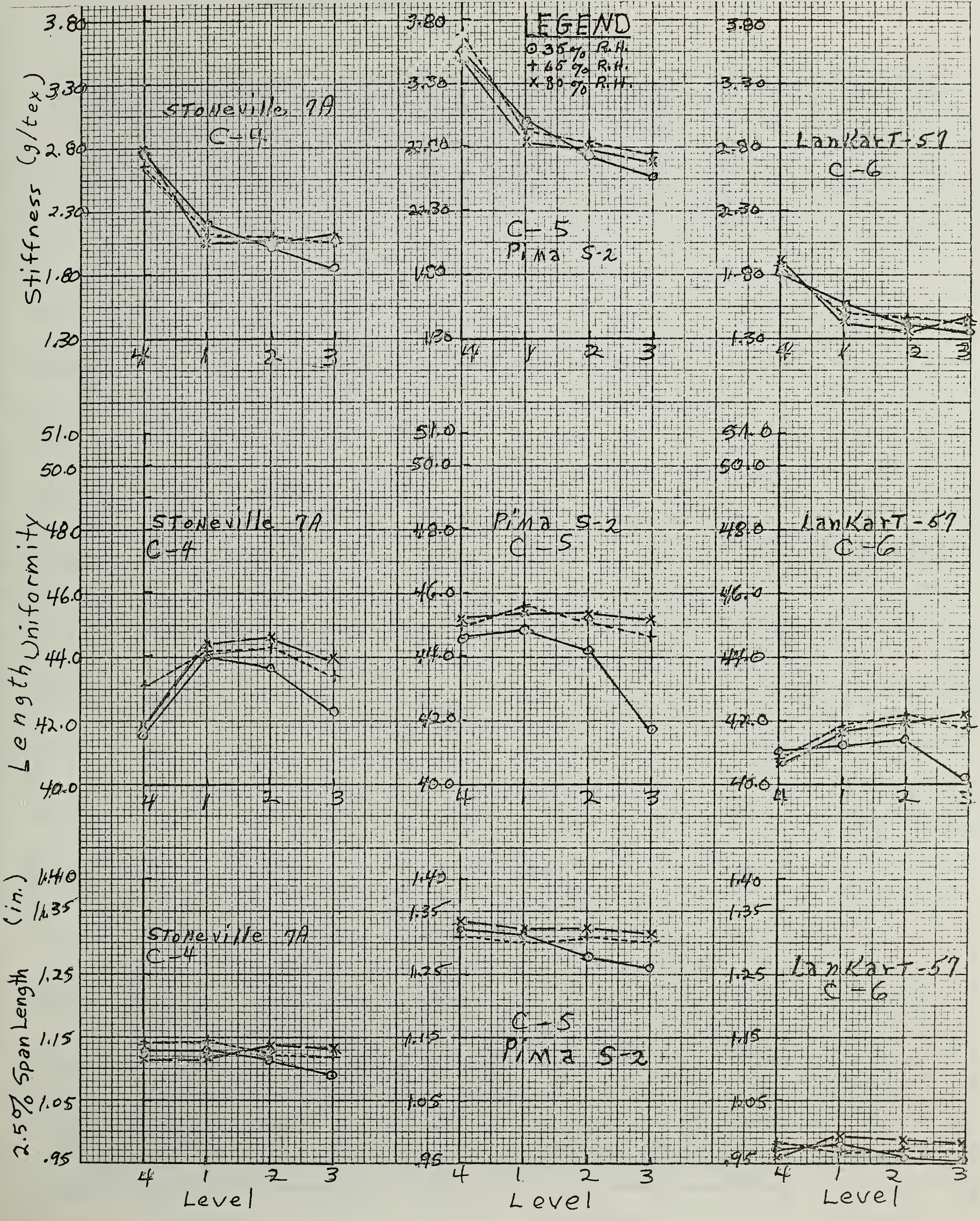


Figure B-13. Crushing level-humidity interactions for fineness on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42 (6 modifications).

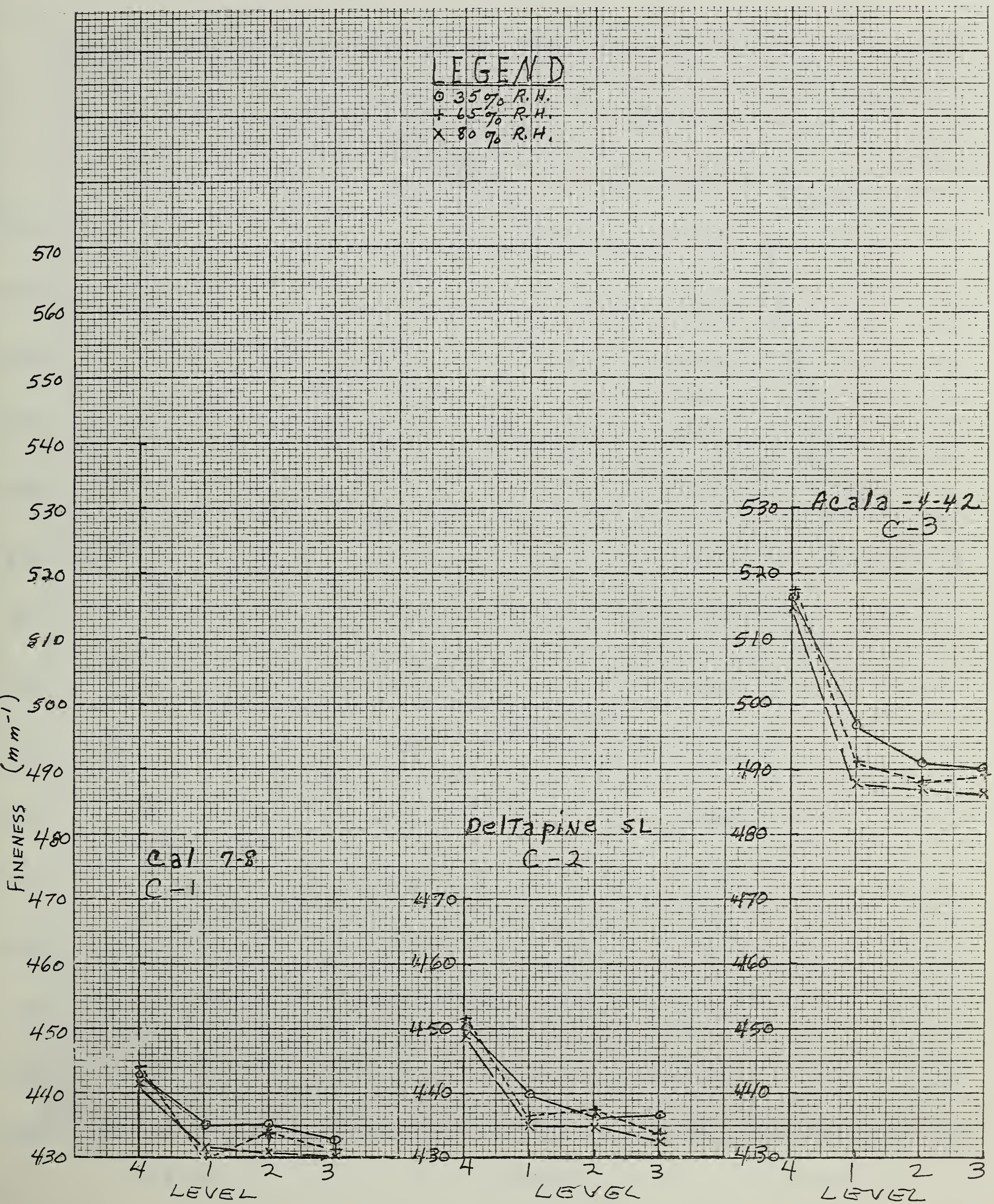
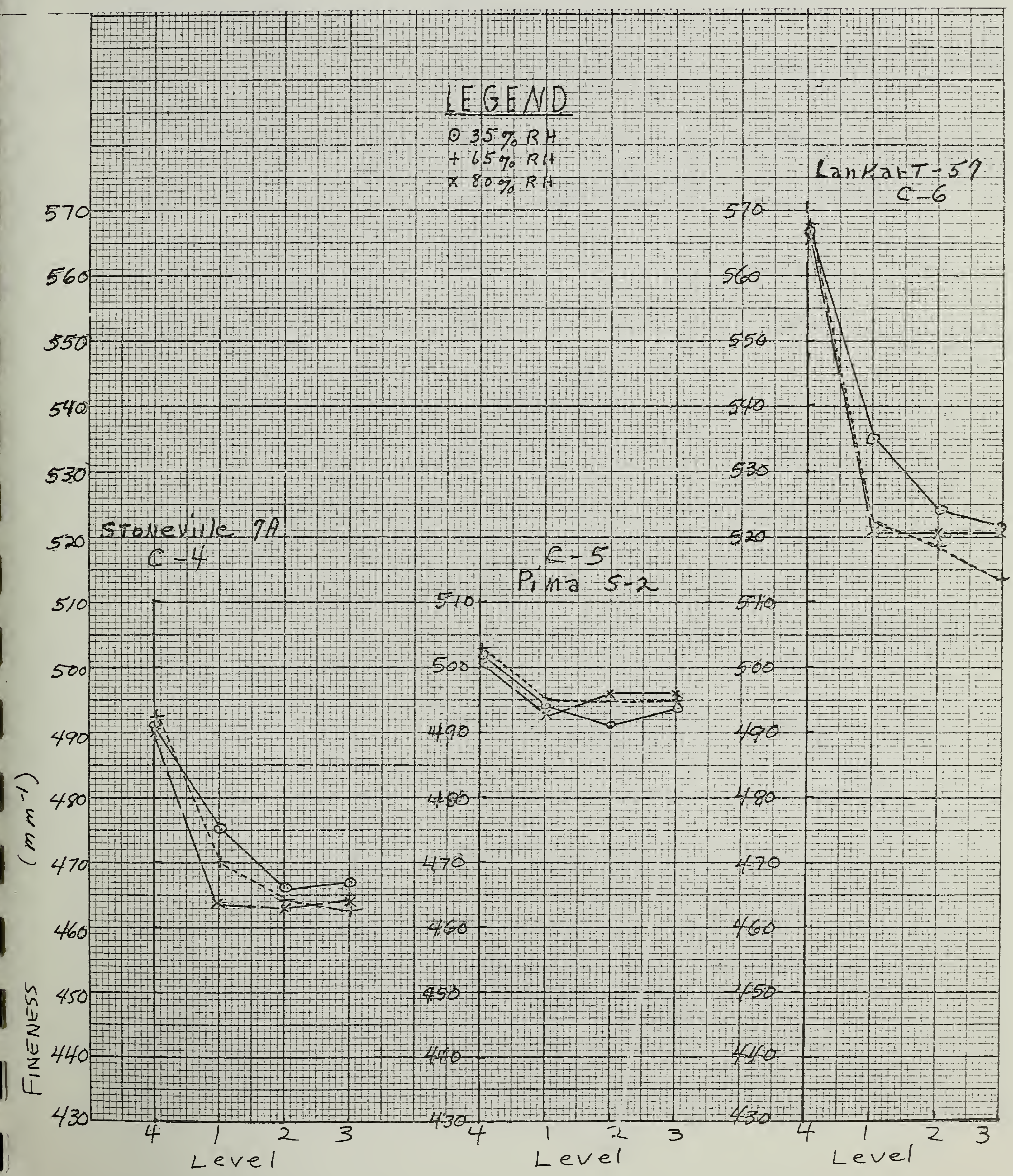


Figure B-14. Crushing level-humidity interactions for fineness on Stoneville 7A, Pima S-2 and Lankart 57 (6 modifications).



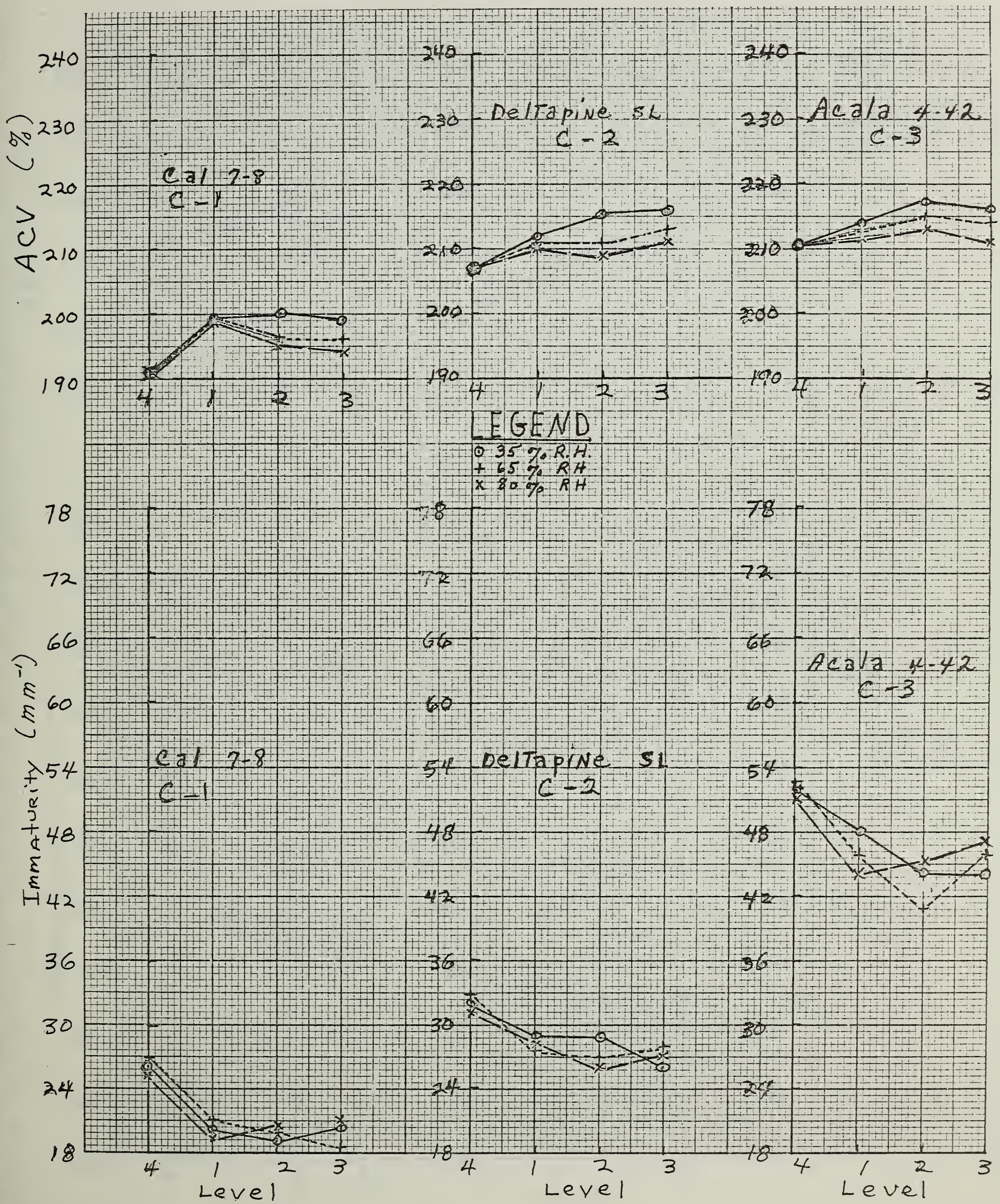
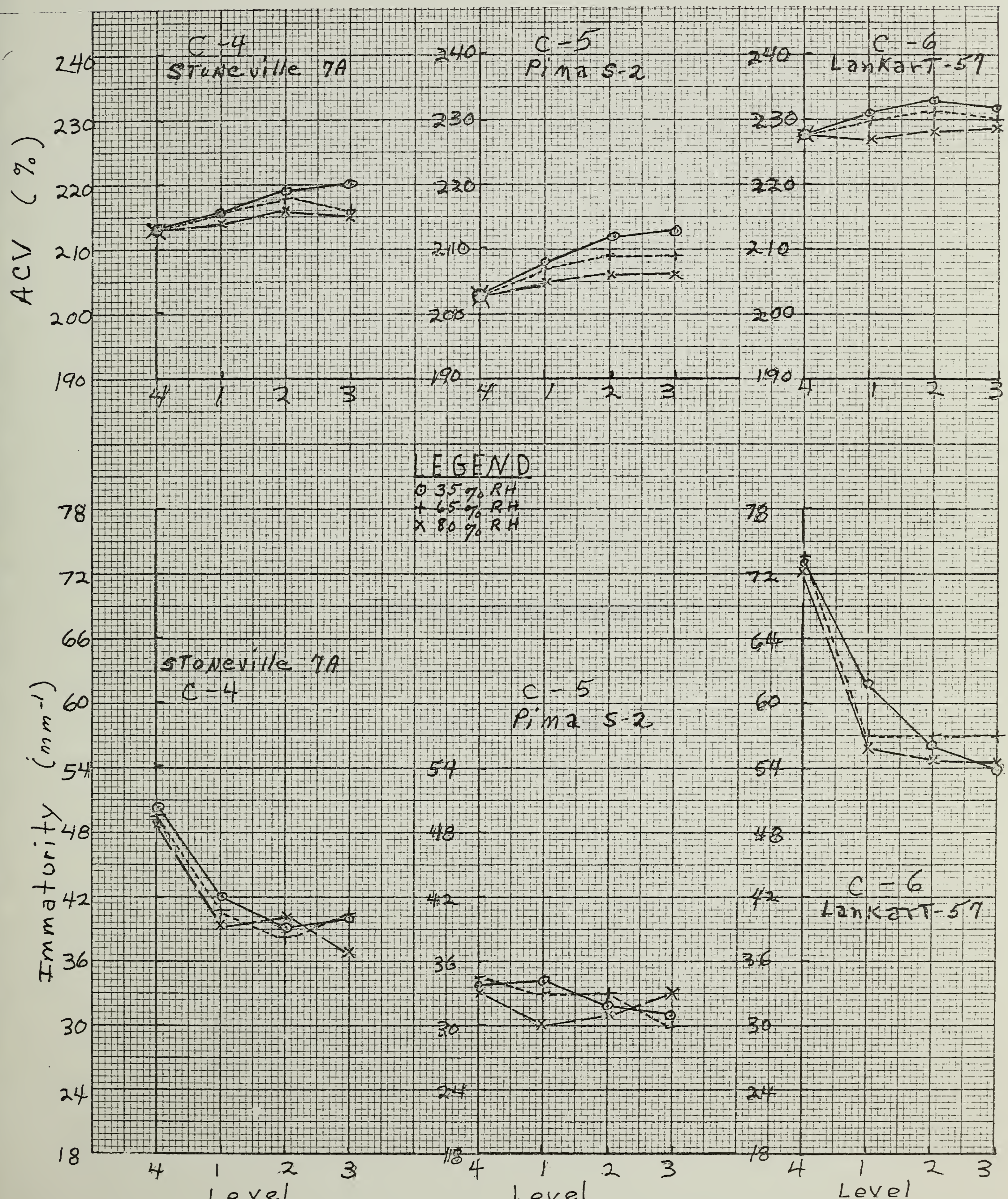


Figure B-15. Crushing level-humidity interactions for ACV and immaturity on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42 (6 modifications).

Figure B-16. Crushing level-humidity interactions for ACV and immaturity on Stoneville 7A, Pima S-2 and Lankart 57 (6 modifications).



SECTION XI

APPENDIX C

MECHANICAL WORKING TREATMENT

(Tables and Graphs)

TABLE C-L Fiber Property Means for Each Variety on the Mechanically Worked Samples and the Significance at the 5 Per Cent Level

Variety	Tenacity 1/8 in. Gauge g/tex		Elongation %		Toughness g/tex		Impact Strength g/tex		50% Span Length in.	
Cal 7-8	22.64	B	6.96	E	0.812	E	20.11	B	0.499	B
DP-SL	20.18	D	9.82	A	0.994	B	17.81	D	0.461	D
A 4-42	21.59	C	8.65	C	0.951	C	19.03	C	0.481	C
ST. 7A	19.08	E	7.66	D	0.744	F	16.07	E	0.451	E
P. S-2	28.90	A	9.00	B	1.297	A	26.47	A	0.549	A
L 57	17.28	F	9.95	A	0.868	D	15.17	F	0.380	F

Variety	2.5% Span Length in.		Fineness mm^{-1}		Immaturity mm^{-1}		ACV %	
Cal 7-8	1.039	D	428.3	F	24.3	E	200.4	D
DP-SL	1.083	B	439.3	E	30.1	D	210.6	C
A 4-42	1.062	C	495.3	B	46.3	B	218.1	B
St. 7A	1.080	B	472.3	D	39.2	C	217.2	B
P. S-2	1.252	A	480.3	C	29.2	D	210.1	C
L 57	0.937	E	529.3	A	59.0	A	229.1	A

[1] These are all the means within a variety of all the modifications, mechanical working levels and mechanical working humidities combined.

TABLE C-II. Effect of Modification and Mechanical Working Treatments on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(a) Tenacity 1/8 in. Gauge (g/tex)

Modification	Variety												All Varieties	
	Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57			
Control	22.50	BC	20.06	BC	21.44	C	18.95	C	29.50	B	17.32	C	21.63	C
35%-72°C	22.41	C	19.92	C	21.41	C	18.97	C	29.25	BC	17.09	C	21.51	CD
65%-72°C	22.21	C	19.97	BC	21.18	C	18.77	C	28.89	CD	16.97	C	21.33	D
80%-72°C	22.44	BC	20.28	B	21.16	C	18.80	C	28.81	CD	17.11	C	21.43	CD
35%-180°C	21.35	D	19.73	CD	20.24	D	17.92	D	27.79	D	16.20	D	20.54	E
65%-180°C	20.92	D	19.55	D	20.14	D	18.15	D	27.86	D	16.07	D	20.45	E
Alcohol	23.00	B	21.01	A	22.62	B	19.89	B	30.46	A	18.48	B	22.58	B
NaOH	26.32	A	20.91	A	24.55	A	21.22	A	28.62	D	19.01	A	23.44	A
Level of mechanical working														
No MW	22.51	B	19.90	B	21.42	B	18.86	B	28.80	A	17.19	B	21.45	B
MW	22.78	A	20.46	A	21.76	A	19.31	A	29.00	A	17.38	A	21.78	A
Humidity for mechanical working														
35%	22.41	B	20.13	A	21.34	B	18.99	B	28.52	B	17.22	A	21.44	C
65%	22.69	AB	20.15	A	21.57	AB	18.92	B	29.10	A	17.27	A	21.62	B
80%	22.84	A	20.26	A	21.87	A	19.35	A	29.07	A	17.36	A	21.79	A

TABLE C–II. Effect of Modification and Mechanical Working Treatments on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(b) Per Cent Elongation (%)

Modification	Variety						All Varieties
	Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	
Control	5.63 CD	9.05 B	7.48 B	6.50 BC	8.11 BCD	8.82 DE	7.60 CD
35%-72°C	5.94 B	8.87 BC	7.46 B	6.52 BC	8.07 BCD	8.55 E	7.57 CD
65%-72°C	5.89 BC	8.82 BC	7.52 B	6.57 B	8.19 BC	9.25 BC	7.71 BC
80%-72°C	5.74 BCD	9.17 B	7.58 B	6.58 B	8.33 B	9.38 B	7.80 B
35%-180°C	5.53 D	8.57 C	7.43 B	6.57 B	8.00 CD	9.17 BC	7.55 CD
65%-180°C	5.58 D	8.56 C	7.30 B	6.42 C	7.79 D	8.94 CD	7.43 D
Alcohol	4.93 E	7.68 D	6.17 C	5.96 D	6.50 E	7.58 F	6.47 E
NaOH	16.43 A	17.82 A	18.25 A	16.13 A	17.02 A	17.90 A	17.26 A
Level of mechanical working							
No MW	7.02 A	9.94 A	8.69 A	7.73 A	9.23 A	10.01 A	8.77 A
MW	6.90 A	9.69 B	8.61 A	7.59 B	8.77 B	9.89 A	8.58 B
Humidity for mechanical working							
35%	6.95 A	9.77 A	8.69 AB	7.63 B	9.09 A	9.89 A	8.67 A
65%	6.97 A	9.87 A	8.75 A	7.73 A	8.96 A	10.00 A	8.71 A
80%	6.97 A	9.82 A	8.51 B	7.61 B	8.95 A	9.96 A	8.64 A

TABLE C-II. Effect of Modification and Mechanical Working Treatments on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(c) Toughness (g/tex)

Modification	Variety: Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	All Varieties
Control	0.633 C	0.907 BC	0.803 B	0.620 B	1.196 B	0.764 CD	0.821 B
35%-72°C	0.664 B	0.886 C	0.798 B	0.620 B	1.179 B	0.732 E	0.813 B
65%-72°C	0.654 BC	0.883 C	0.796 B	0.617 B	1.182 B	0.786 BC	0.820 B
80%-72°C	0.646 BC	0.927 B	0.799 B	0.620 B	1.200 B	0.802 B	0.832 B
35%-180°C	0.589 D	0.844 D	0.750 C	0.588 C	1.112 C	0.741 DE	0.771 C
65%-180°C	0.584 D	0.836 D	0.735 C	0.584 C	1.085 C	0.719 EF	0.757 C
Alcohol	0.567 D	0.808 D	0.693 D	0.590 C	0.987 D	0.701 F	0.724 D
NaOH	2.162 A	1.862 A	2.232 A	1.710 A	2.431 A	1.701 A	2.016 A
Level of mechanical working							
No MW	0.816 A	0.994 A	0.951 A	0.744 A	1.328 A	0.868 A	0.950 A
MW	0.809 A	0.994 A	0.951 A	0.744 A	1.265 B	0.868 A	0.939 B
Humidity for mechanical working							
35%	0.800 B	0.987 A	0.947 A	0.737 A	1.295 A	0.858 B	0.937 A
65%	0.814 A	0.998 A	0.963 A	0.746 A	1.299 A	0.873 A	0.949 A
80%	0.823 A	0.997 A	0.943 A	0.748 A	1.296 A	0.873 A	0.947 A

TABLE C—II. Effect of Modification and Mechanical Working Treatments on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(d) Impact Strength (g/tex)

Modification	Variety						All Varieties
	Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	
Control	19.12 BC	17.57 B	18.49 B	15.32 D	26.54 B	15.26 B	18.71 B
35%-72°C	19.37 B	17.39 BC	18.39 B	15.72 BC	26.54 B	15.06 BC	18.75 B
65%-72°C	19.14 BC	17.56 B	18.36 B	15.27 D	26.45 B	15.02 BC	18.63 B
80%-72°C	19.27 BC	17.52 BC	18.09 B	15.46 CD	26.01 BC	14.95 BC	18.55 B
35%-180°C	18.66 BC	17.02 CD	17.29 C	14.63 E	25.17 C	14.82 C	17.93 C
65%-180°C	18.52 C	16.77 D	17.37 C	15.15 D	25.26 C	14.38 D	17.91 C
Alcohol	18.97 BC	17.72 B	18.46 B	15.91 B	26.00 BC	15.20 BC	18.71 B
NaOH	27.87 A	20.95 A	25.85 A	21.13 A	29.82 A	19.12 A	24.12 A
Level of mechanical working							
No MW	19.90 B	17.62 B	18.86 B	15.96 B	26.50 A	15.43 A	19.05 B
MW	20.33 A	18.00 A	19.21 A	16.19 A	26.45 A	15.53 A	19.28 A
Humidity for mechanical working							
35%	19.64 B	17.59 B	18.69 C	15.75 B	26.10 B	15.18 C	18.82 C
65%	20.31 A	17.71 B	19.04 B	16.18 A	26.59 AB	15.43 B	19.21 B
80%	20.40 A	18.13 A	19.37 A	16.30 A	26.73 A	15.82 A	19.46 A

TABLE C-II. Effect of Modification and Mechanical Working Treatments on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(e) 50 Per Cent Span Length (in.)

Modification	Variety: Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	All Varieties
Control	0.507 B	0.478 AB	0.508 A	0.473 A	0.586 A	0.393 AB	0.491 A
35%-72°C	0.521 AB	0.485 A	0.503 A	0.475 A	0.573 A	0.386 ABC	0.491 A
65%-72°C	0.516 AB	0.480 AB	0.499 A	0.467 AB	0.579 A	0.395 A	0.489 A
80%-72°C	0.528 A	0.472 AB	0.495 A	0.474 A	0.587 A	0.397 A	0.492 A
35%-180°C	0.508 B	0.462 AB	0.484 AB	0.452 B	0.562 A	0.385 ABC	0.476 B
65%-180°C	0.518 AB	0.457 BC	0.488 A	0.458 AB	0.553 A	0.379 BC	0.476 B
Alcohol	0.428 D	0.413 D	0.421 C	0.374 D	0.448 C	0.333 D	0.402 D
NaOH	0.467 C	0.438 C	0.457 B	0.431 C	0.500 B	0.375 C	0.445 C
Level of mechanical working							
No MW	0.515 A	0.482 A	0.498 A	0.473 A	0.582 A	0.385 A	0.489 A
MW	0.484 B	0.440 B	0.464 B	0.428 B	0.515 B	0.376 B	0.451 B
Humidity of mechanical working							
35%	0.492 B	0.449 B	0.480 A	0.447 A	0.550 A	0.373 B	0.465 C
65%	0.501 AB	0.459 B	0.479 A	0.451 A	0.539 A	0.379 AB	0.468 B
80%	0.506 A	0.475 A	0.483 A	0.453 A	0.556 A	0.389 A	0.477 A

TABLE C-II. Effect of Modification and Mechanical Working Treatments on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(f) 2.5 Per Cent Span Length (in.)

Modification	Variety: Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	All Varieties
Control	1.064 A	1.116 A	1.100 A	1.127 A	1.309 A	0.967 A	1.114 A
35%-72°C	1.072 A	1.117 A	1.097 A	1.127 A	1.302 A	0.962 A	1.113 A
65%-72°C	1.069 A	1.117 A	1.097 A	1.122 A	1.299 A	0.969 A	1.112 A
80%-72°C	1.077 A	1.113 A	1.097 A	1.122 A	1.303 A	0.962 A	1.113 A
35%-180°C	1.062 A	1.100 A	1.086 A	1.107 A	1.292 A	0.959 A	1.101 A
65%-180°C	1.067 A	1.098 A	1.086 A	1.104 A	1.283 A	0.956 A	1.099 A
Alcohol	0.976 B	1.019 B	0.985 B	0.952 B	1.099 B	0.863 B	0.982 B
NaOH	0.927 C	0.986 B	0.946 B	0.980 B	1.124 B	0.852 B	0.969 B
Level of mechanical working							
No MW	1.059 A	1.117 A	1.087 A	1.122 A	1.296 A	0.959 A	1.107 A
MW	1.020 B	1.049 B	1.037 B	1.037 B	1.207 B	0.914 B	1.044 B
Humidity of mechanical working							
35%	1.031 B	1.064 B	1.064 A	1.074 A	1.259 A	0.923 B	1.069 B
65%	1.039 AB	1.082 AB	1.060 A	1.085 A	1.242 A	0.934 B	1.074 AB
80%	1.048 A	1.104 A	1.061 A	1.081 A	1.253 A	0.953 A	1.083 A

TABLE C-II. Effect of Modification and Mechanical Working Treatments on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(g) Fineness (mm^{-1})

Modification	Variety: Cal 7-8	Deltapine SL	Acala 4-42	Stoneville 7A	Pima S-2	Lankart 57	All Varieties
Control	440.7 A	454.9 A	514.9 A	488.9 B	494.0 AB	554.3 A	491.3 A
35%-72°C	439.8 A	454.6 A	512.8 A	490.6 AB	498.5 A	552.5 A	491.5 A
65%-72°C	443.1 A	453.7 A	513.5 A	492.0 AB	496.8 A	552.2 A	491.9 A
80%-72°C	442.5 A	457.3 A	513.3 A	490.0 AB	493.7 AB	552.2 A	491.5 A
35%-180°C	440.6 A	453.9 A	516.3 A	491.3 AB	495.6 A	553.2 A	491.8 A
65%-180°C	444.7 A	455.3 A	515.9 A	495.0 A	494.8 AB	554.3 A	493.3 A
Alcohol	428.2 B	445.6 B	498.2 B	473.2 C	488.3 B	526.8 B	476.7 B
NaOH	347.2 C	339.6 C	378.2 C	358.1 D	381.0 C	389.4 C	365.6 C
Level of mechanical working							
No MW	431.7 A	442.0 A	502.2 A	479.9 A	484.2 A	551.4 A	481.9 A
MW	425.0 B	436.7 B	488.6 B	464.9 B	476.5 B	507.4 B	466.5 B
Humidity of mechanical working							
35%	429.4 A	438.6 A	497.0 A	471.6 A	480.2 A	530.2 AB	474.5 A
65%	427.7 A	438.8 A	495.1 A	473.4 A	481.7 A	526.6 B	473.9 A
80%	428.0 A	440.6 A	494.0 A	472.2 A	479.2 A	531.4 A	474.2 A

TABLE C-II. Effect of Modification and Mechanical Working Treatments on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(h) Immaturity (mm^{-1})

Modification	Variety												All Varieties	
	Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57			
Control	28.4	A	36.2	AB	53.9	A	47.4	A	33.2	AB	67.3	A	44.4	A
35%-72°C	31.0	A	36.8	A	54.9	A	46.4	AB	33.4	AB	68.2	A	45.1	A
65%-72°C	28.9	A	33.5	AB	53.2	A	47.7	A	33.0	B	68.7	A	44.2	A
80%-72°C	28.7	A	37.1	A	53.4	A	43.2	B	36.9	A	69.4	A	44.8	A
35%-180°C	27.5	A	33.9	AB	54.1	A	45.5	AB	36.3	AB	69.3	A	44.4	A
65%-180°C	28.0	A	32.8	B	55.6	A	46.2	AB	34.0	AB	67.1	A	43.9	A
Alcohol	11.8	B	22.8	C	35.2	B	27.0	C	17.5	C	45.7	B	26.6	B
NaOH	10.2	B	7.8	D	10.2	C	10.3	D	9.2	D	16.8	C	10.8	C
Level of mechanical working														
No MW	25.4	A	29.5	A	47.1	A	41.6	A	28.6	A	64.2	A	39.4	A
MW	23.2	B	30.8	A	45.4	A	36.9	B	29.8	A	53.9	B	36.6	B
Humidity of mechanical working														
35%	23.8	A	28.2	B	45.2	A	37.2	B	27.8	B	59.9	A	37.0	B
65%	23.8	A	31.2	A	47.3	A	40.6	A	28.7	B	57.6	A	38.2	A
80%	25.3	A	31.0	A	46.4	A	39.8	A	31.1	A	59.7	A	38.9	A

TABLE C-II. Effect of Modification and Mechanical Working Treatments on Fiber Properties with the Relative Significance as Tested by the Duncan's Multiple Range Test at the 5 Per Cent Level

(i) Alkali Centrifuge (%)

Modification	Variety: Cal 7-8		Deltapine SL		Acala 4-42		Stoneville 7A		Pima S-2		Lankart 57		All Varieties	
Control	199.7	C	207.8	D	216.3	AB	216.4	B	205.4	BC	229.7	B	212.2	C
35%-72°C	198.5	C	208.8	CD	216.6	AB	217.6	B	204.7	BC	231.1	B	212.9	C
65%-72°C	197.9	C	209.0	CD	217.0	AB	216.0	B	203.5	BC	230.2	B	212.3	C
80%-72°C	198.7	C	209.5	BCD	218.0	A	214.7	B	204.5	BC	231.5	AB	212.8	C
35%-180°C	204.8	B	217.0	AB	221.7	A	218.8	B	214.5	B	232.4	AB	218.2	B
65%-180°C	203.9	B	216.0	ABC	222.0	A	219.9	B	215.7	B	229.7	B	217.9	B
Alcohol	213.8	A	220.0	A	224.8	A	231.7	A	234.6	A	236.5	A	226.9	A
NaOH	188.0	D	196.6	E	208.2	B	202.4	C	198.1	C	211.6	C	200.8	D
Level of mechanical working														
No MW	191.6	B	201.9	B	212.2	B	210.4	B	200.4	B	225.3	B	207.0	B
MW	209.2	A	219.2	A	224.0	A	224.1	A	219.9	A	232.9	A	221.6	A
Humidity of mechanical working														
35%	203.2	A	214.4	A	218.5	A	217.7	A	209.2	A	230.6	A	215.6	A
65%	199.5	B	210.0	B	217.0	A	215.9	A	210.5	A	229.2	AB	213.7	B
80%	198.5	B	207.3	B	218.8	A	218.0	A	210.7	A	227.5	B	213.5	B

TABLE C-III. Correlation Coefficients of Combinations of Properties on Data From Mechanically Worked Samples of Cal 7-8

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.34	-0.25	-0.40	-0.39	-0.62	-0.35	0.20	-0.17
D	-0.53	-0.62	-0.51	-0.54	0.73	0.82	0.69	
A	-0.91	-0.88	-0.94	-0.95	0.44	0.78		
2.5% SL	-0.60	-0.69	-0.60	-0.63	0.86			
50% SL	-0.25	-0.40	-0.21	-0.24				
Tou.	0.93	0.85	1.00					
E_1.	0.92	0.82						
T_1.	0.87							
			(b) Six Modifications[1,2]					
ACV	0.02	-0.22	-0.16	-0.25	-0.65	-0.71	-0.22	-0.19
D	0.08	0.12	0.21	0.23	0.25	0.38	0.30	
A	-0.08	-0.32	0.37	0.15	0.14	0.27		
2.5% SL	0.05	0.02	0.40	0.34	0.76			
50% SL	0.07	0.07	0.11	0.14				
Tou.	0.59	0.55	0.85					
E_1.	0.40	0.04						
T_1.	0.45							

[1] The total number of paired observations is 96 and 72 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, two mechanical workings and three mechanical working humidities. For 96 and 72 paired values, r = 0.20 and 0.23 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE C-IV. Correlation Coefficients of Combinations of Properties on Data From Mechanically Worked Samples of Deltapine Smooth Leaf

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.36	0.12	-0.48	-0.46	-0.65	-0.48	0.34	0.16
D	-0.64	-0.44	-0.72	-0.74	0.47	0.68	0.83	
A	-0.86	-0.47	-0.95	-0.96	0.30	0.58		
2.5% SL	-0.45	-0.60	-0.41	-0.45	0.88			
50% SL	-0.17	-0.57	-0.11	-0.16				
Tou.	0.85	0.42	1.00					
E_1.	0.83	0.33						
T_1.	0.55							
			(b) Six Modifications[1,2]					
ACV	-0.14	0.22	-0.40	-0.19	-0.80	-0.90	-0.52	-0.07
D	0.34	0.32	0.07	0.20	0.13	0.08	0.05	
A	-0.08	-0.38	0.23	-0.04	0.53	0.58		
2.5% SL	0.13	-0.35	0.25	0.00	0.90			
50% SL	0.12	-0.33	0.18	-0.03				
Tou.	0.31	0.70	0.86					
E_1.	0.12	0.26						
T_1.	0.44							

[1] The total number of paired observations is 96 and 72 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, two mechanical workings and three mechanical working humidities. For 96 and 72 paired values, $r = 0.20$ and 0.23 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE C-V. Correlation Coefficients of Combinations of Properties on Data From Mechanically Worked Samples of Acala 4-42

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.29	-0.01	-0.42	-0.39	-0.55	-0.41	0.19	0.12
D	-0.83	-0.84	-0.80	-0.83	0.53	0.80	0.89	
A	-0.93	-0.82	-0.92	-0.95	0.38	0.72		
2.5% SL	-0.59	-0.77	-0.49	-0.54	0.85			
50% SL	-0.25	-0.51	-0.12	-0.16				
Tou.	0.92	0.72	1.00					
E_1.	0.89	0.66						
T_1.	0.84							
			(b) Six Modifications[1,2]					
ACV	-0.11	-0.19	-0.22	-0.29	-0.54	-0.65	-0.39	0.12
D	-0.01	-0.04	-0.46	-0.37	0.11	0.20	-0.11	
A	-0.33	-0.27	0.21	0.03	0.35	0.49		
2.5% SL	0.02	0.11	-0.12	-0.03	0.86			
50% SL	0.08	0.19	-0.17	-0.02				
Tou.	0.62	0.60	0.83					
E_1.	0.26	0.06						
T_1.	0.75							

[1] The total number of paired observations is 96 and 72 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, two mechanical workings and three mechanical working humidities. For 96 and 72 paired values, r = 0.20 and 0.23 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE C-VI. Correlation Coefficients of Combinations of Properties on Data From Mechanically Worked Samples of Stoneville 7-A

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.36	0.04	-0.48	-0.45	-0.65	-0.58	0.27	-0.02
D	-0.80	-0.76	-0.74	-0.77	0.60	0.77	0.86	
A	-0.94	-0.77	-0.95	-0.96	0.32	0.56		
2.5% SL	-0.45	-0.66	-0.34	-0.39	0.91			
50% SL	-0.22	-0.46	-0.11	-0.14				
Tou.	0.92	0.71	1.00					
E_1.	0.91	0.65						
T_1.	0.74							
			(b) Six Modifications[1,2]					
ACV	-0.11	0.11	-0.21	-0.11	-0.75	-0.87	-0.54	-0.26
D	-0.14	0.09	-0.06	0.00	0.40	0.42	0.29	
A	-0.28	-0.33	0.12	-0.17	0.55	0.64		
2.5% SL	-0.01	-0.05	0.11	0.08	0.91			
50% SL	-0.01	0.05	-0.02	0.05				
Tou.	0.48	0.62	0.63					
E_1.	0.26	-0.19						
T_1.	0.30							

[1] The total number of paired observations is 96 and 72 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, two mechanical workings and three mechanical working humidities. For 96 and 72 paired values, r = 0.20 and 0.23 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE C-VII. Correlation Coefficients of Combinations of Properties on Data From Mechanically Worked Samples of Pima S-2

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
				(a) Eight Modifications[1]				
ACV	-0.43	0.26	-0.39	-0.38	-0.77	-0.74	0.11	-0.16
D	-0.41	-0.19	-0.55	-0.57	0.57	0.67	0.69	
A	-0.68	0.05	-0.91	-0.91	0.38	0.52		
2.5% SL	-0.09	-0.34	-0.24	-0.26	0.94			
50% SL	-0.01	-0.34	-0.09	-0.11				
Tou.	0.70	-0.12	1.00					
E_1.	0.66	-0.21						
T_1.	0.16							
				(b) Six Modifications[1,2]				
ACV	-0.23	-0.41	-0.39	-0.49	-0.80	-0.82	-0.35	0.16
D	0.08	0.05	0.12	0.11	-0.07	-0.03	-0.26	
A	0.13	0.05	-0.11	-0.04	0.27	0.41		
2.5% SL	0.14	0.28	0.24	0.32	0.91			
50% SL	0.12	0.24	0.30	0.34				
Tou.	0.32	0.76	0.84					
E_1.	-0.01	0.29						
T_1.	0.58							

[1] The total number of paired observations is 96 and 72 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, two mechanical workings and three mechanical working humidities. For 96 and 72 paired values, $r = 0.20$ and 0.23 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE C-VIII. Correlation Coefficients of Combination of Properties on Data From Mechanically Worked Samples of Lankart 57

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.65	-0.33	-0.70	-0.69	-0.32	-0.12	0.43	0.35
D	-0.74	-0.74	-0.73	-0.79	0.44	0.81	0.92	
A	-0.82	-0.65	-0.81	-0.85	0.26	0.71		
2.5% SL	-0.39	-0.63	-0.41	-0.47	0.79			
50% SL	0.03	-0.39	0.04	-0.03				
Tou.	0.82	0.62	0.99					
E_1.	0.79	0.51						
T_1.	0.64							
			(b) Six Modifications[1,2]					
ACV	-0.01	-0.05	-0.10	-0.13	-0.17	-0.49	-0.35	-0.20
D	0.02	-0.20	0.06	-0.05	0.36	0.66	0.68	
A	-0.18	-0.15	0.19	0.10	0.20	0.63		
2.5% SL	0.26	0.03	-0.10	-0.06	0.71			
50% SL	0.47	0.22	-0.17	-0.04				
Tou.	0.05	0.46	0.88					
E_1.	-0.18	-0.02						
T_1.	0.43							

[1] The total number of paired observations is 96 and 72 for eight and six modifications respectively with three sets of subgroups consisting of eight or six modifications, two mechanical workings and three mechanical working humidities. For 96 and 72 paired values, $r = 0.20$ and 0.23 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

TABLE C-IX. Correlation Coefficients of Combinations of Properties on Data From Mechanically Worked Samples of Six Varieties Combined

	Imp.	T_1.	E_1.	Tou.	50% SL	2.5% SL	A	D
			(a) Eight Modifications[1]					
ACV	-0.40	-0.30	-0.25	-0.36	-0.67	-0.49	0.46	0.38
D	-0.57	-0.53	-0.39	-0.54	-0.13	0.05	0.87	
A	-0.43	-0.30	-0.57	-0.62	-0.06	0.18		
2.5% SL	0.42	0.51	-0.26	-0.03	0.88			
50% SL	0.52	0.57	-0.16	0.09				
Tou.	0.69	0.47	0.92					
E_1.	0.38	0.10						
T_1.	0.92							
			(b) Six Modifications[1,2]					
ACV	-0.45	-0.50	0.38	-0.15	-0.71	-0.54	0.60	0.68
D	-0.50	-0.55	0.40	-0.19	-0.60	-0.51	0.85	
A	-0.22	-0.28	0.48	0.09	-0.41	-0.23		
2.5% SL	0.82	0.84	-0.05	0.68	0.83			
50% SL	0.75	0.80	-0.31	0.45				
Tou.	0.78	0.75	0.58					
E_1.	-0.01	-0.10						
T_1.	0.97							

[1] The total number of paired observations is 576 and 432 for eight and six modifications respectively with four sets of subgroups consisting of six varieties, eight or six modifications, two mechanical workings and three mechanical working humidities. For 576 and 432 paired values $r = 0.08$ and 0.10 respectively are significant at the 0.05 level.

[2] Alcohol and NaOH modifications are omitted.

Figure C-1. Variety-modification interaction for toughness, 50% span length, 2.5% span length, impact strength, tenacity and elongation on mechanically worked samples.

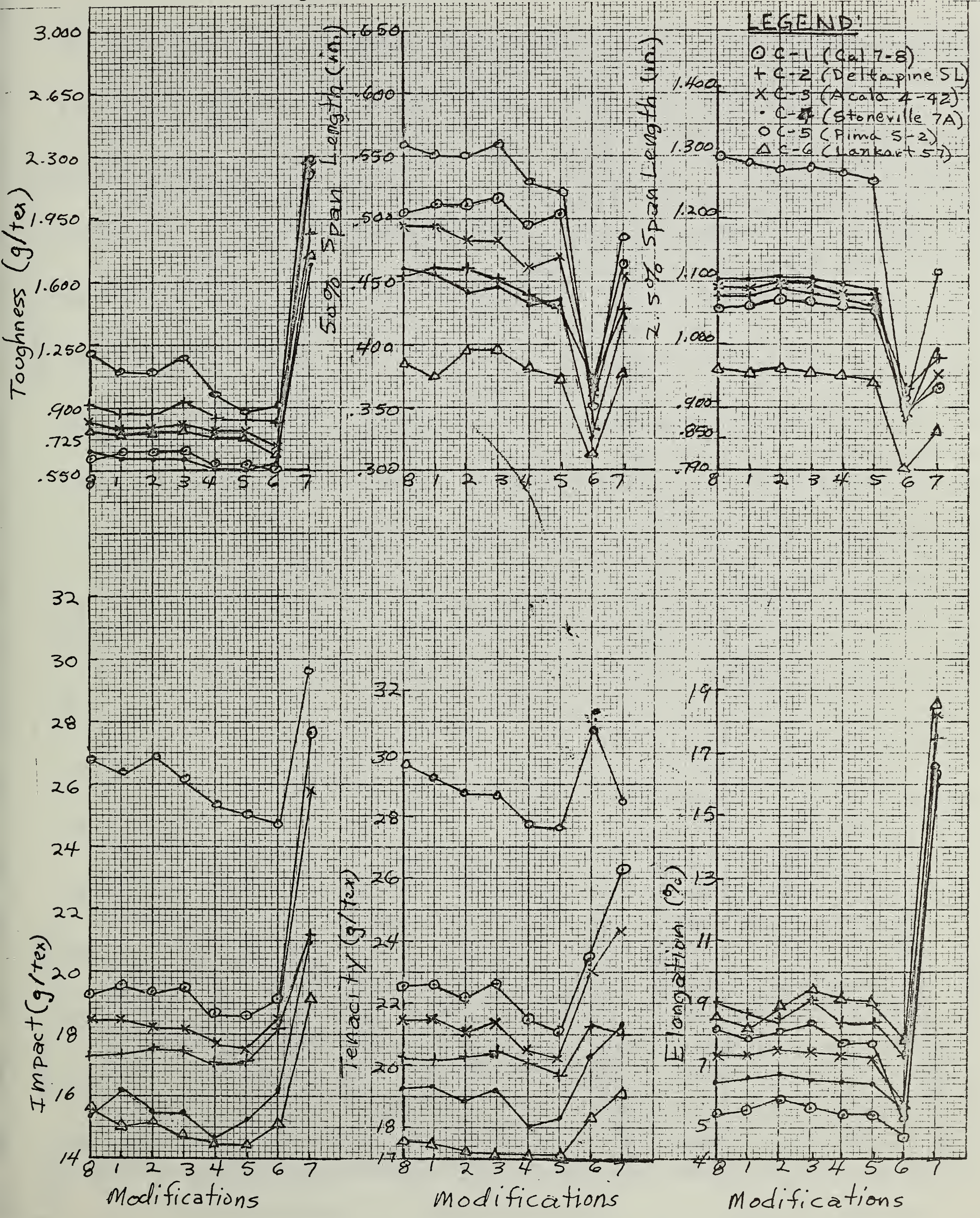


Figure C-2. Variety-modification interaction for immaturity, ACV, length uniformity, stiffness and fineness on mechanically worked samples.

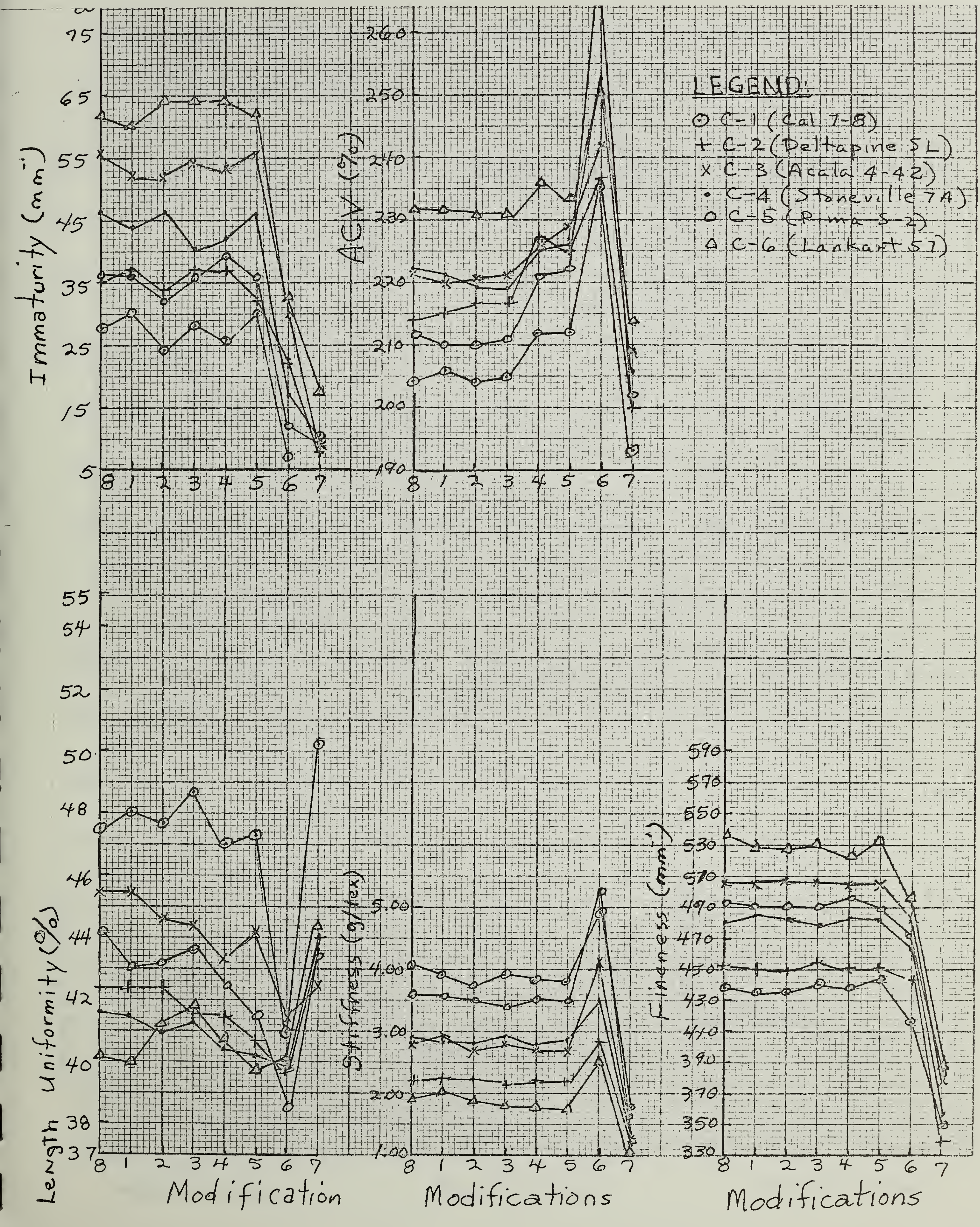


Figure C-3. Modification-mechanically worked interaction for tenacity and impact strength on cottons Cal 7-8, Deltapine Smooth Leaf and Acala 4-42.

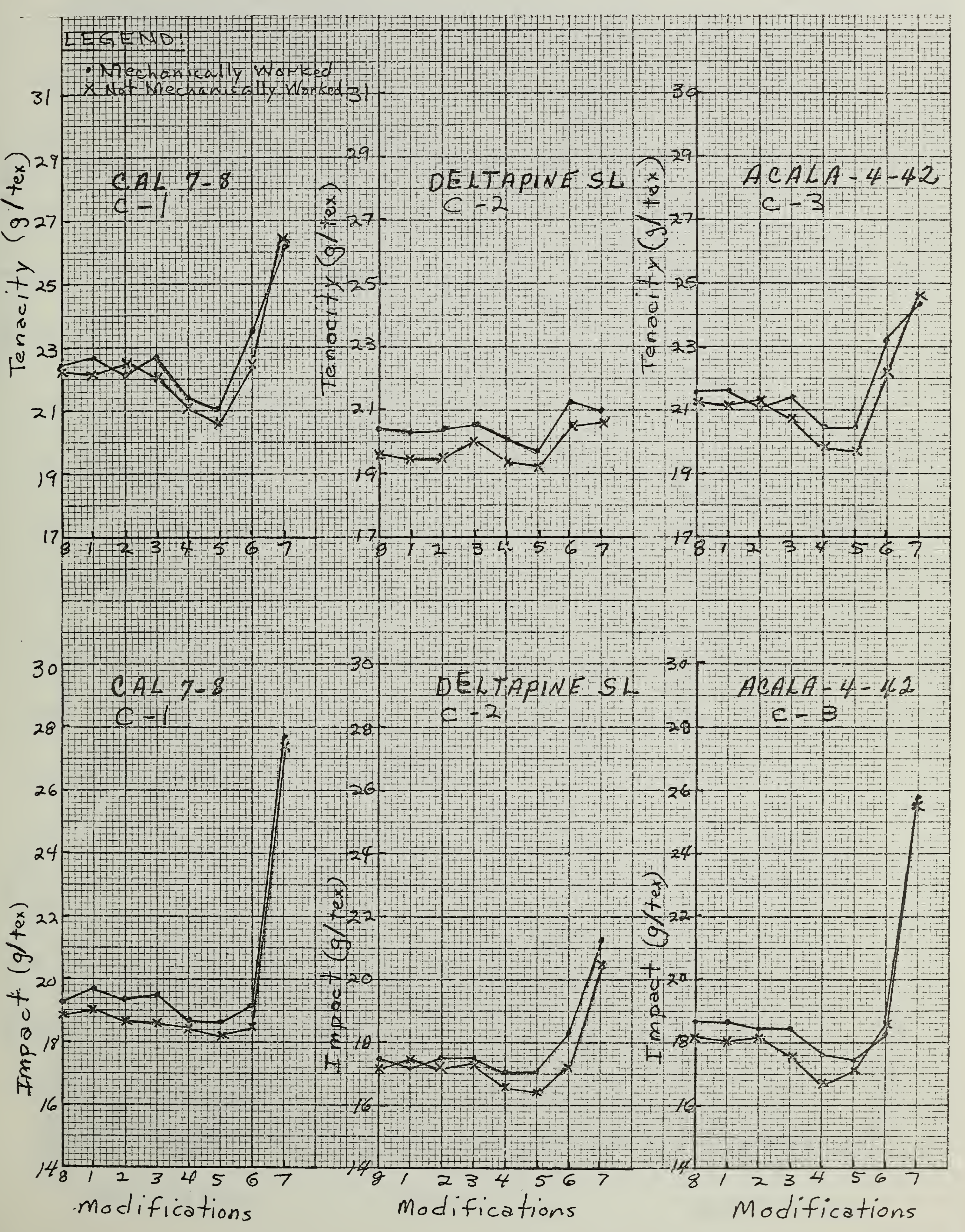


Figure C-4. Modification-mechanically worked interaction for tenacity and impact on Stoneville 7A, Pima S-2 and Lankart 57.

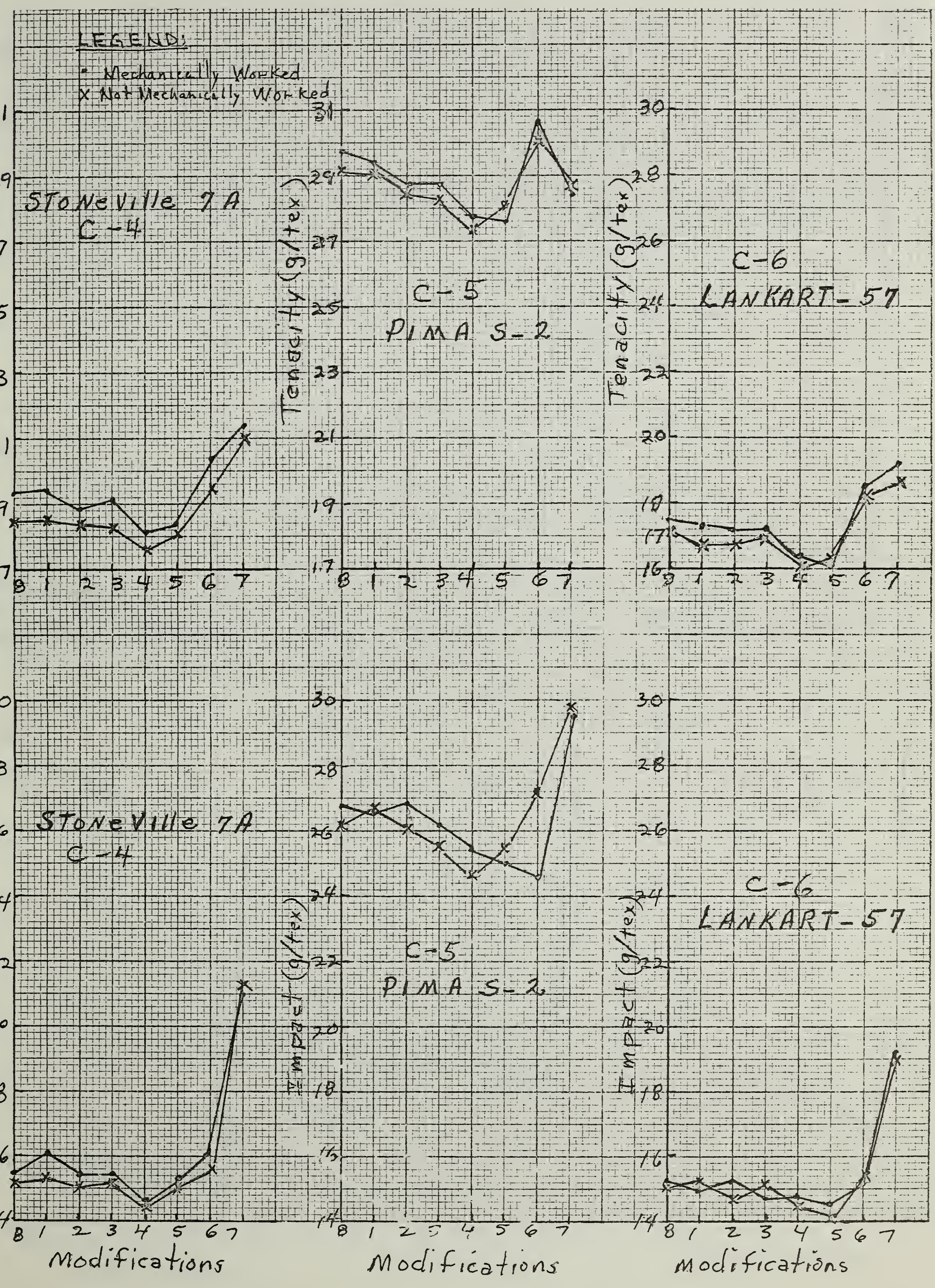


Figure C-5. Modification-mechanically worked interaction for toughness and elongation on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42.

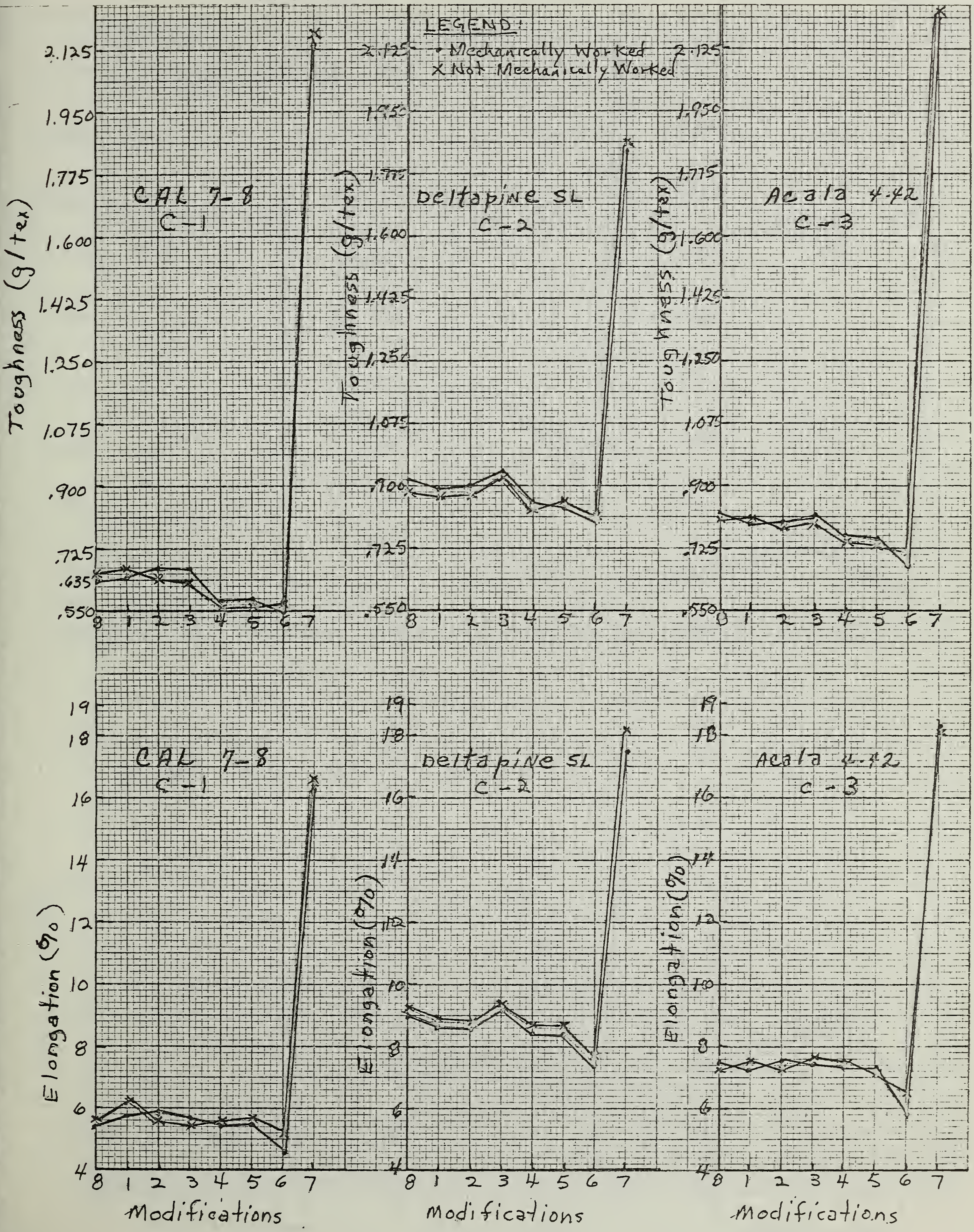
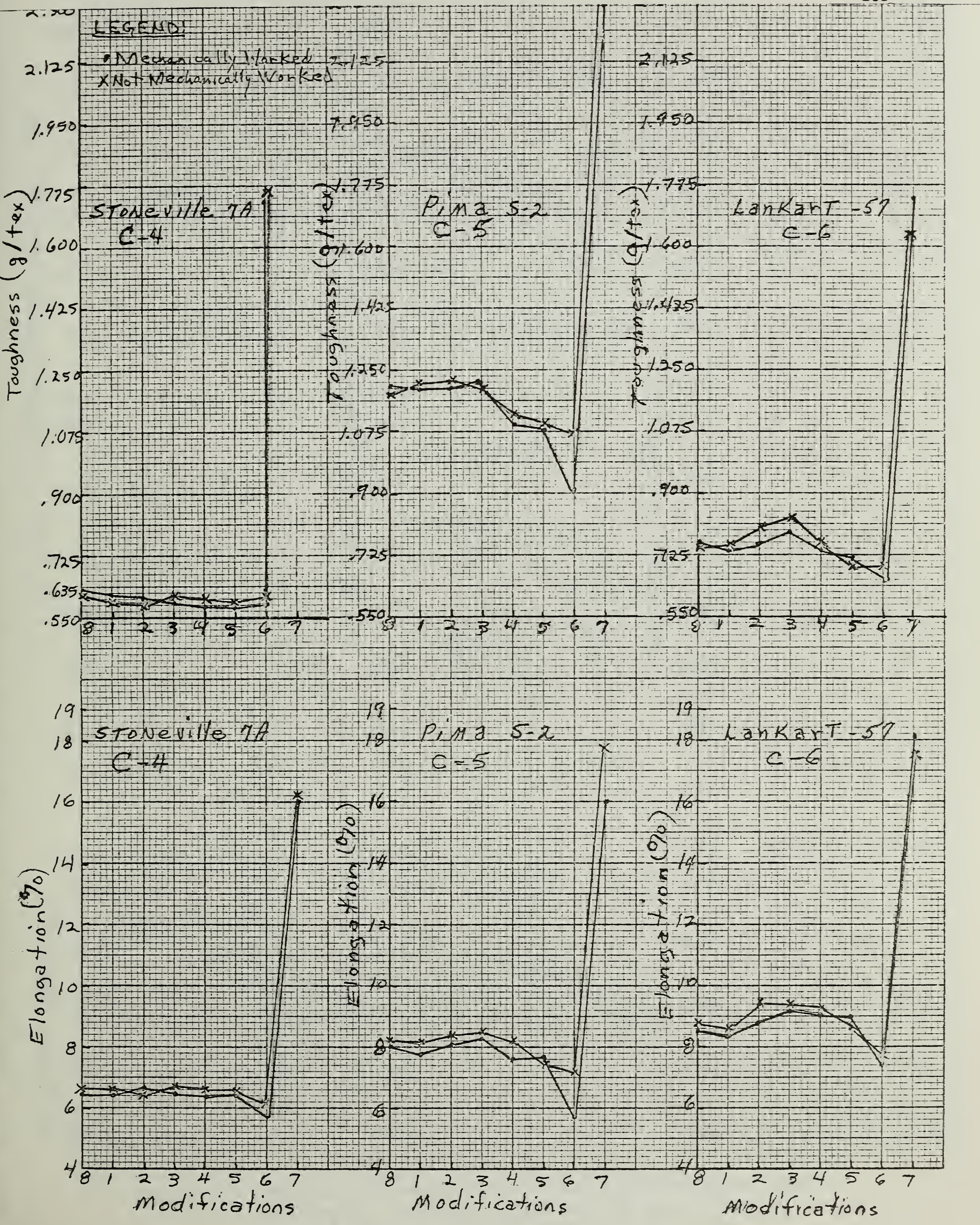


Figure C-6. Modification-mechanically worked interaction for toughness and elongation on Stoneville 7A, Pima S-2 and Lankart 57.



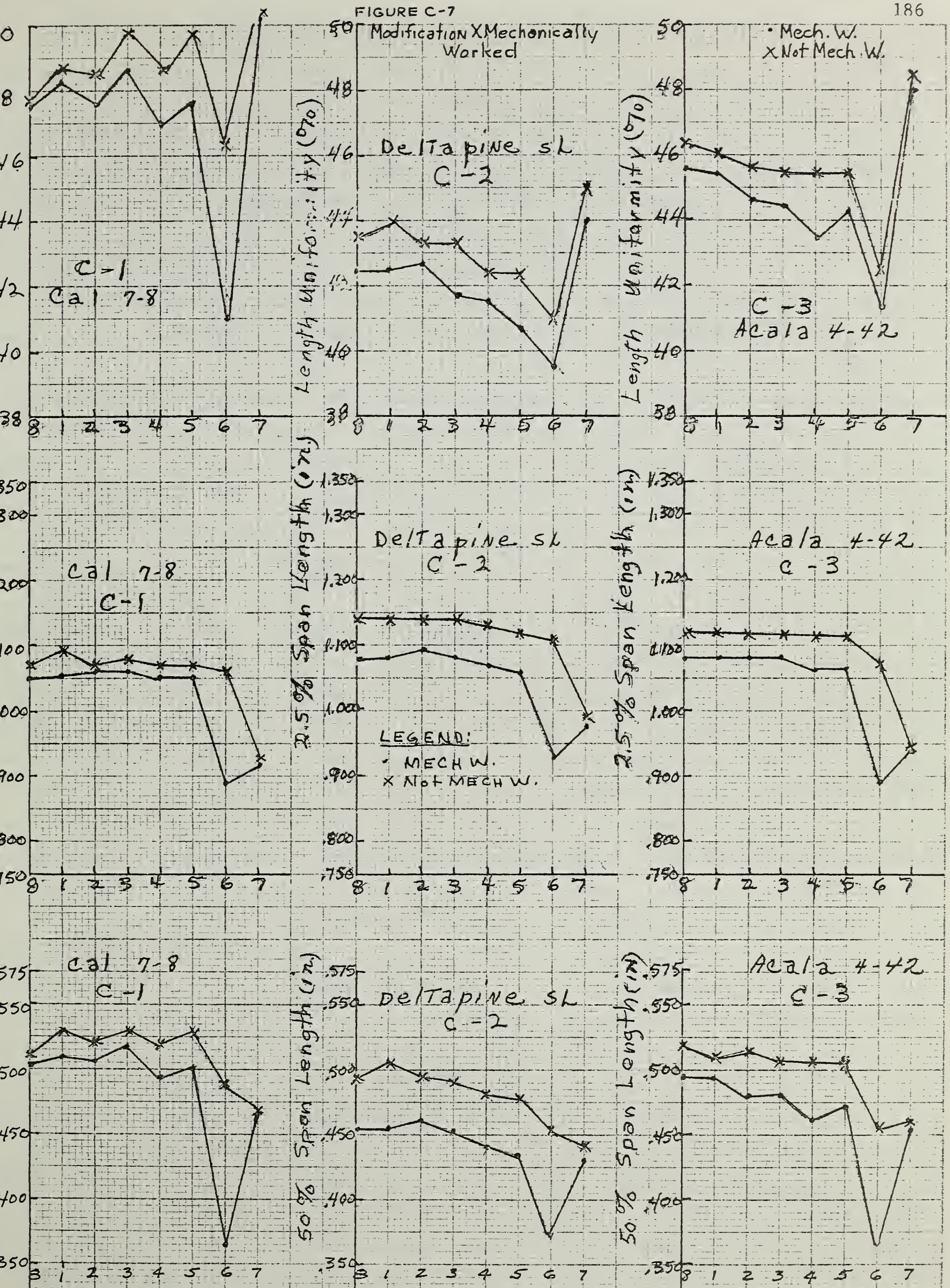


Figure C-7. Modification-mechanically worked interaction for length uniformity, 2.5% span length and 50% span length on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42.

Figure C-8. Modification-mechanically worked interaction for length uniformity, 2.5% span length and 50% span length on Stoneville 7A, Pima S-2, and Lankart 57.

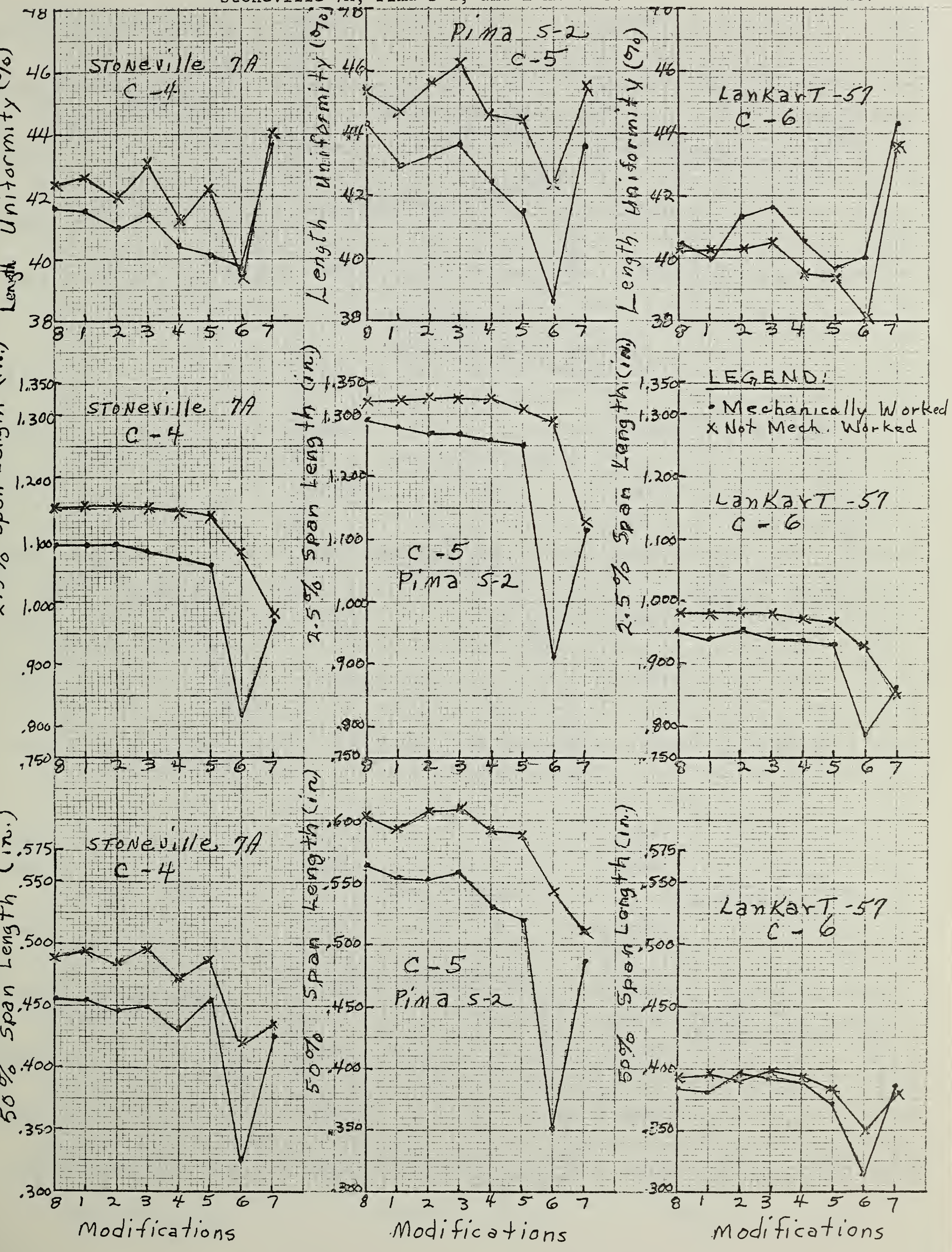


Figure C-9. Modification-mechanically worked interaction for stiffness, immaturity and fineness on Cal 7-8, Deltapine Smooth Leaf and Acala 4-42.

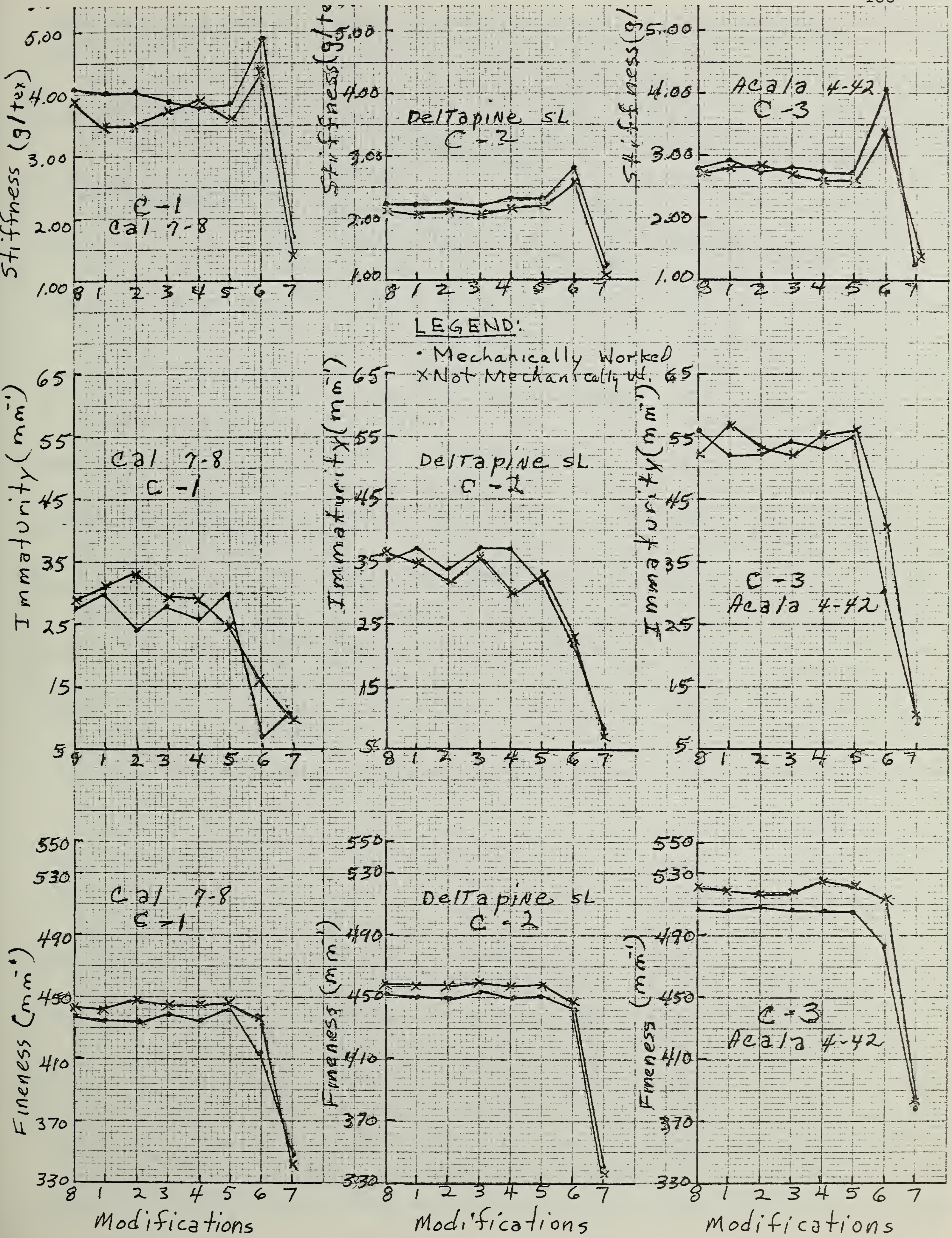


Figure C-10. Modification-mechanically worked interaction for stiffness, immaturity and fineness on Stoneville 7A, Pima S-2 and Lankart 57.

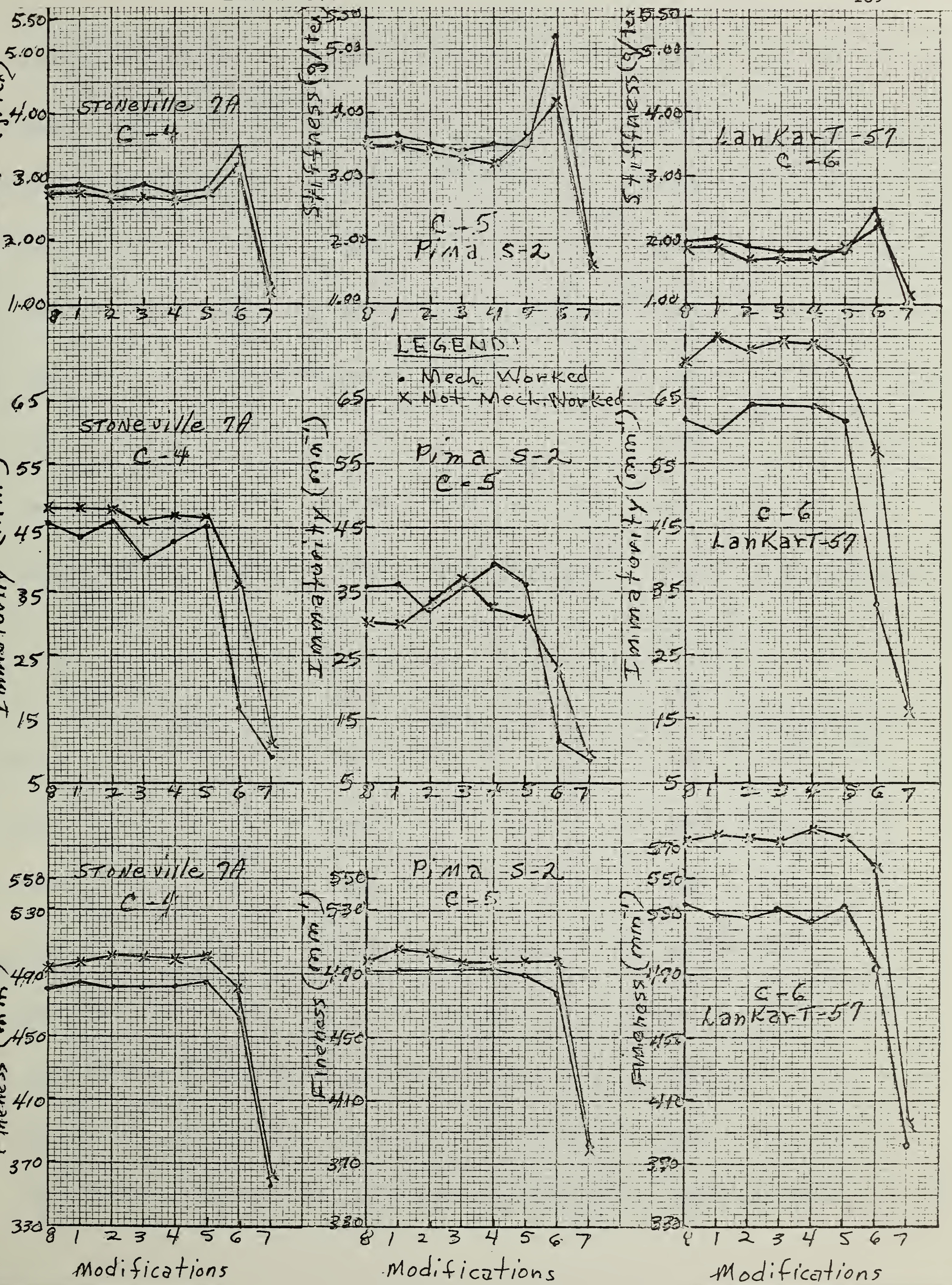


Figure C-11. Modification-mechanically worked interaction for ACV on all varieties.

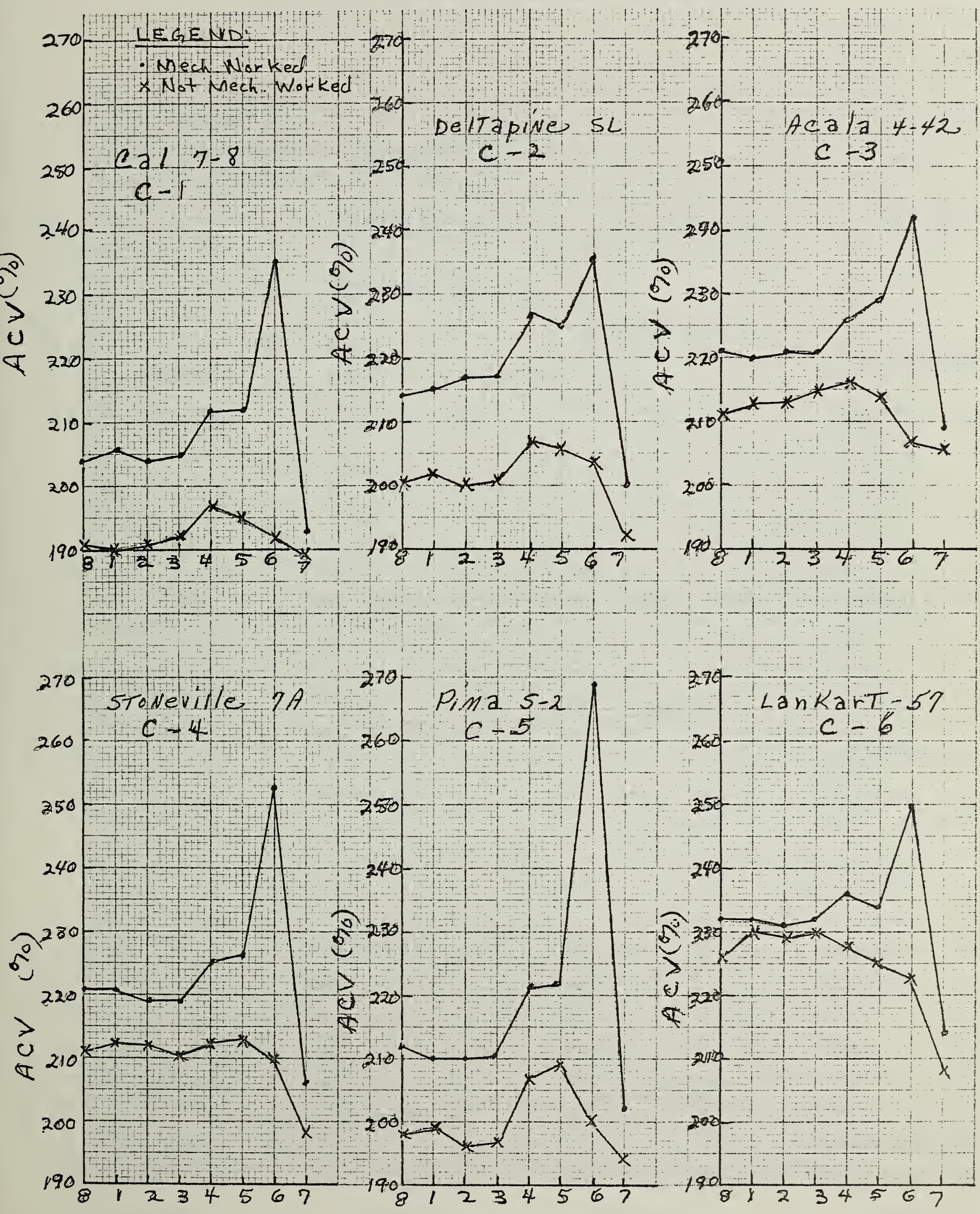


Figure C-12. Humidity-mechanically worked interaction for elongation, tenacity and impact strength on Cal 7-8, Deltapine Smooth Leaf, Acala 4-42 and Stoneville 7A (8 modifications).

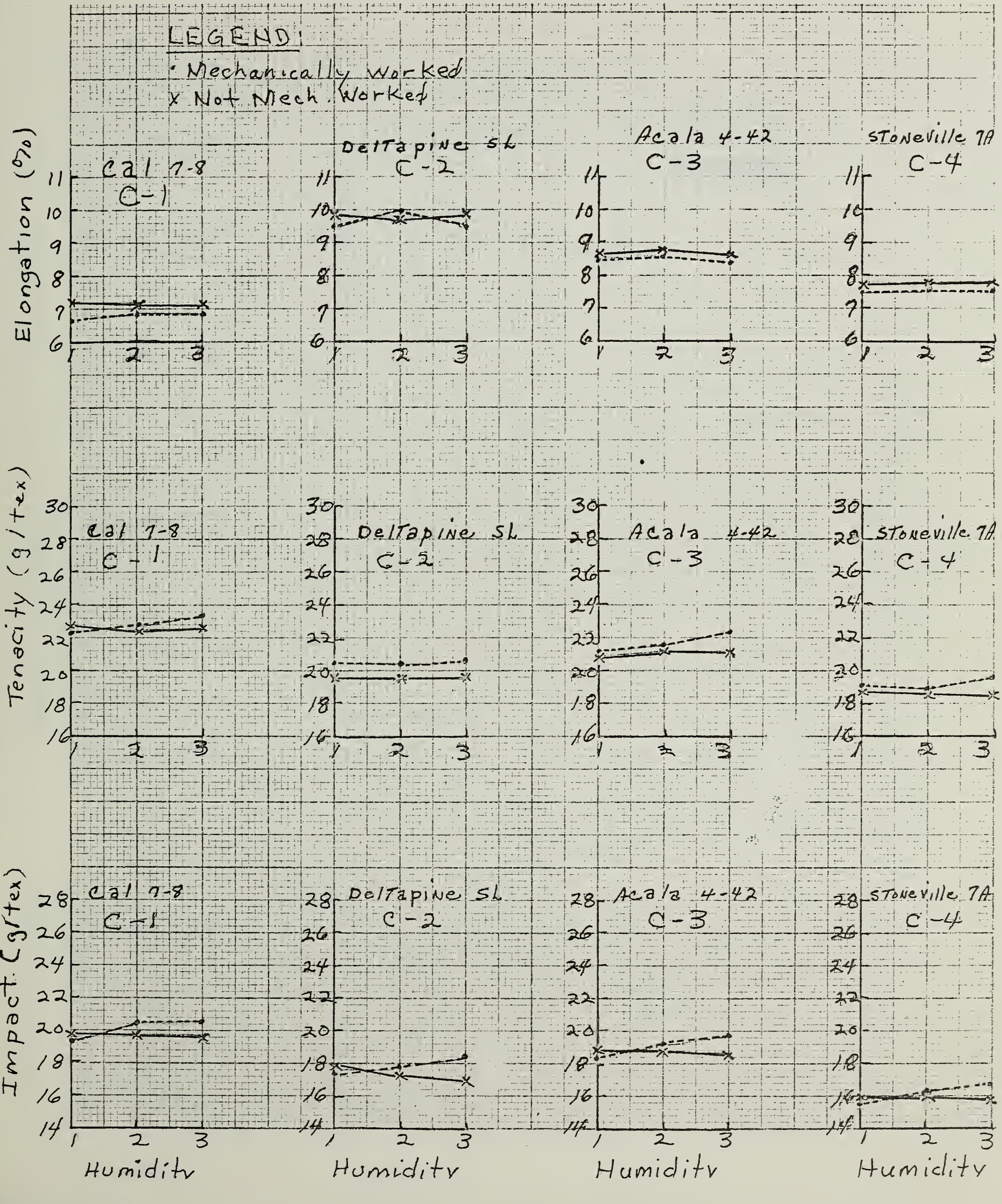


Figure C-13. Humidity-mechanically worked interaction for elongation, tenacity and impact strength on Pima S-2 and Lankart 57 (8 modifications).

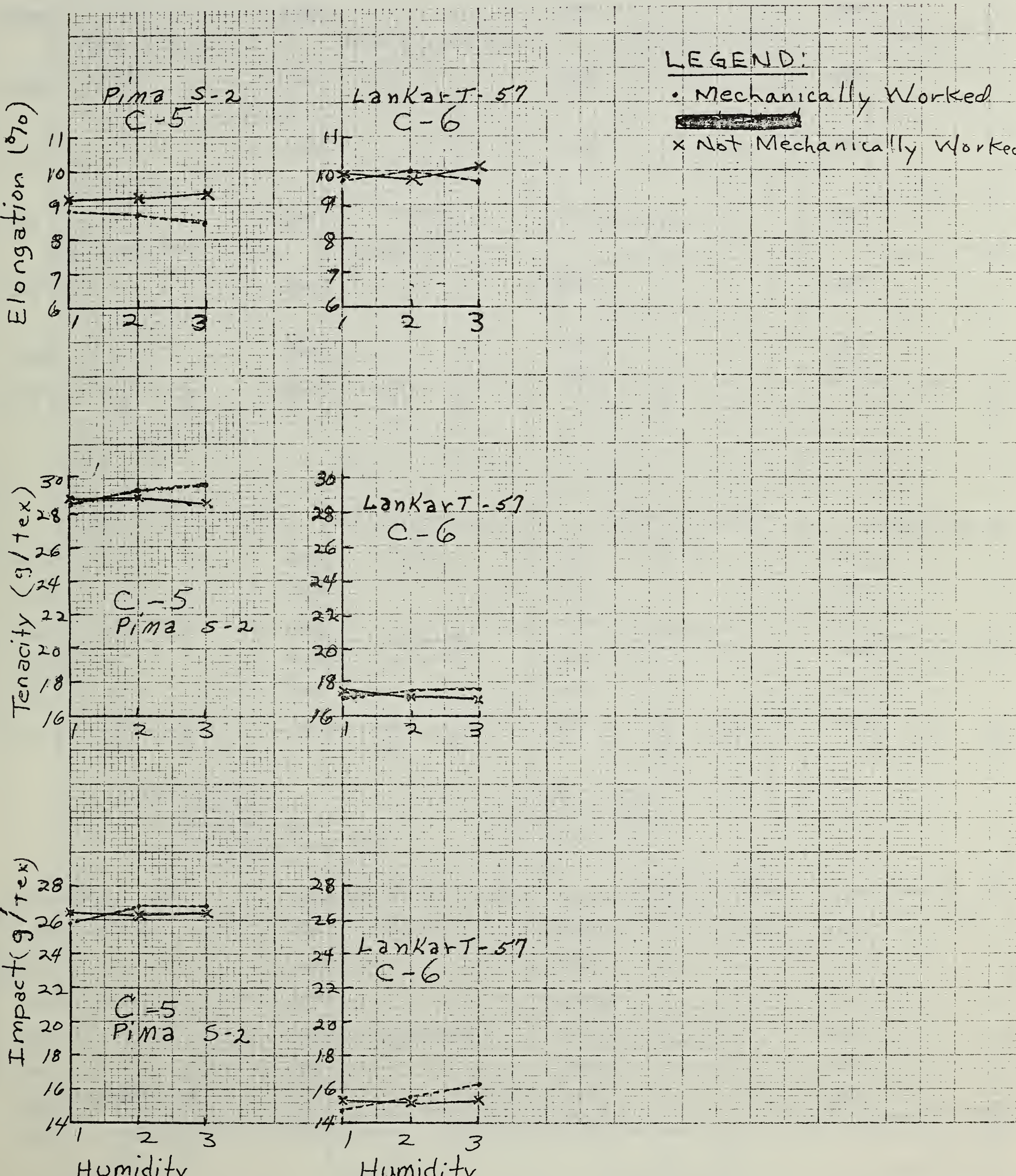


Figure C-14. Humidity-mechanically worked interaction for 2.5% span length, 50% span length and toughness on Cal 7-8, Deltapine Smooth Leaf, Acala 4-42 and Stoneville 7A (8 modifications).

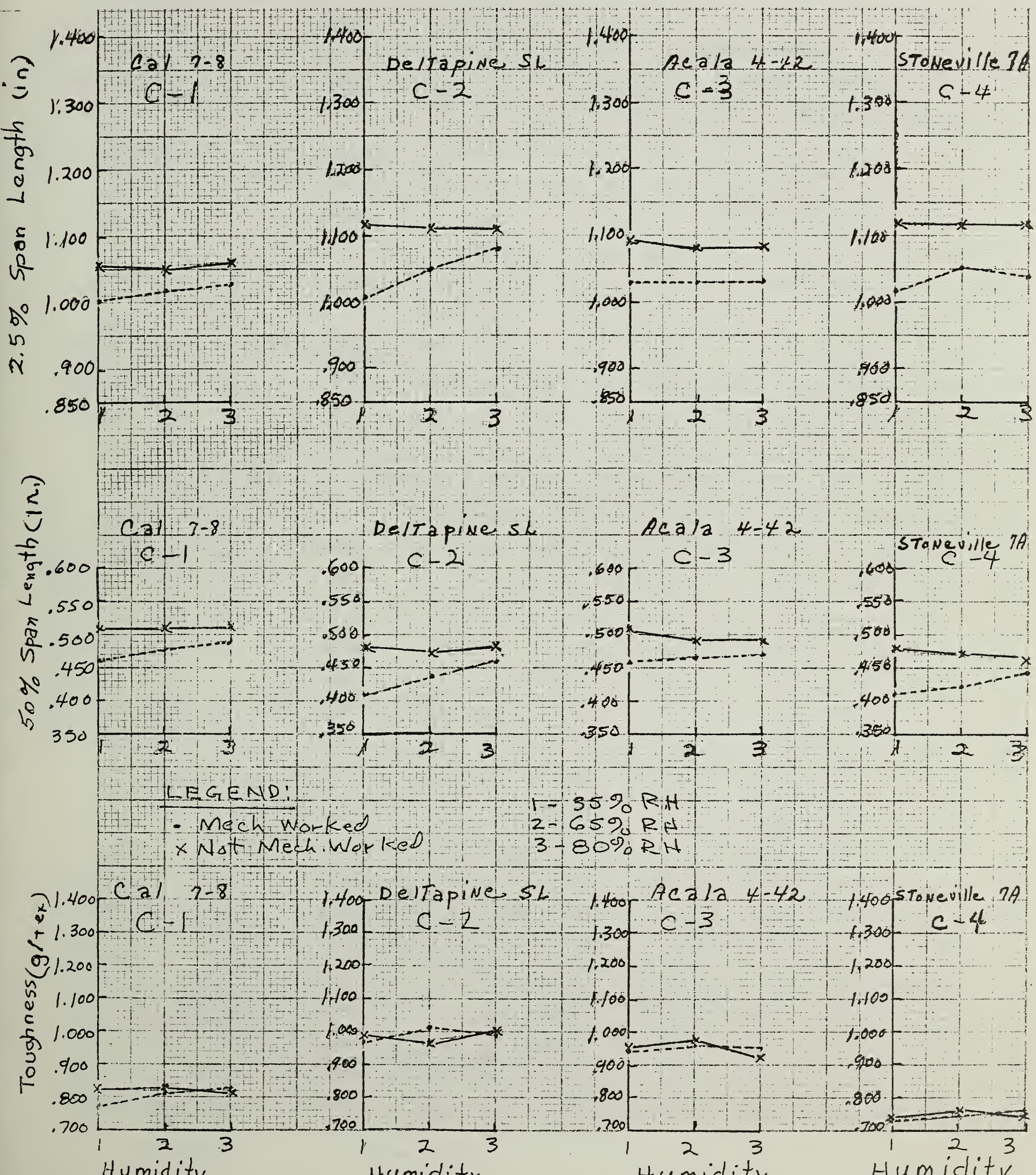


Figure C-15. Humidity-mechanically worked interaction for 2.5% span length, 50% span length and toughness on Pima S-2 and Lankart 57 (8 modifications).

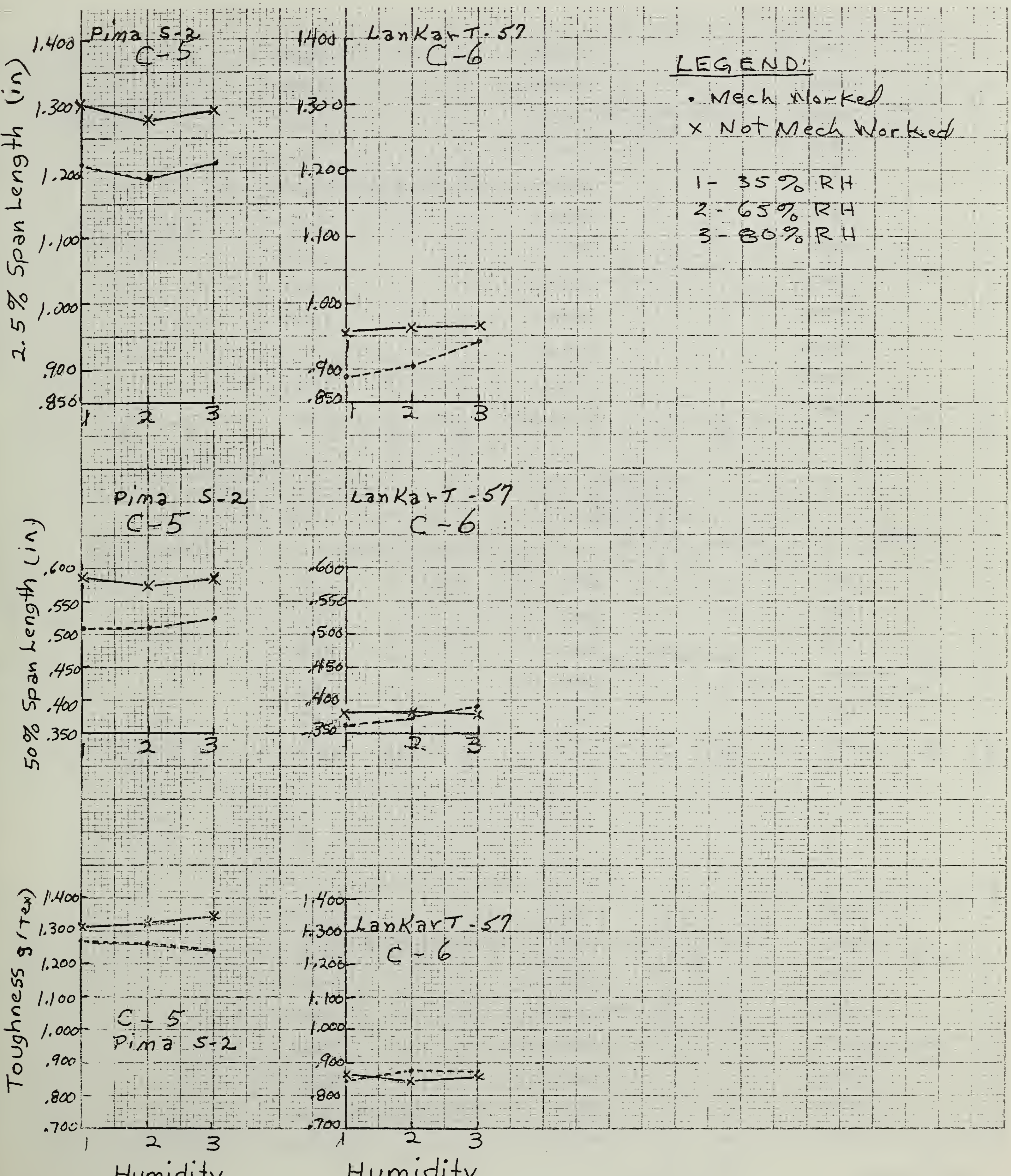


Figure C-16. Humidity-mechanically worked interaction for stiffness, immaturity and fineness on Cal 7-8, Deltapine Smooth Leaf, Acala 4-42 and Stoneville 7A (8 modifications).

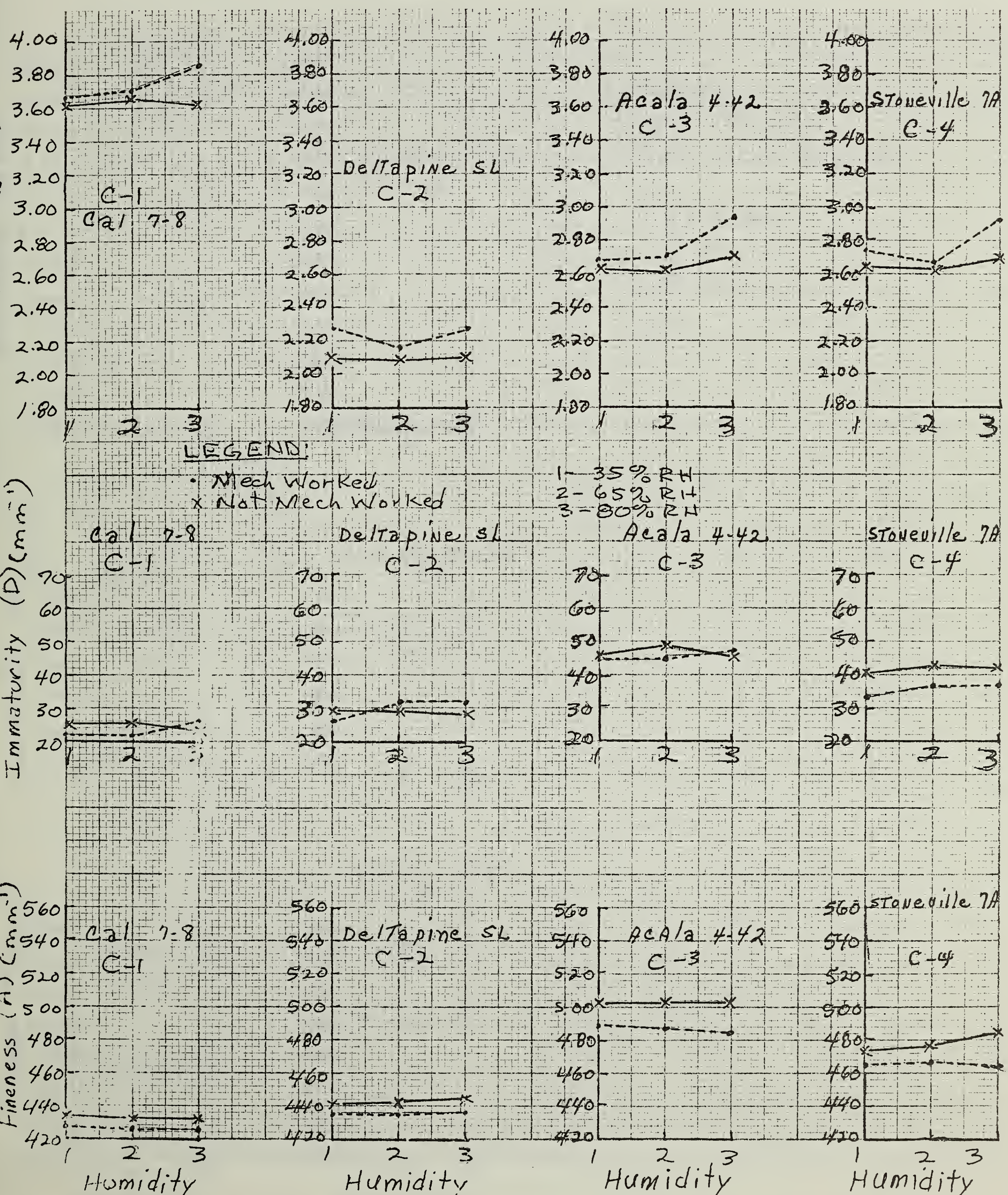


Figure C-17. Humidity-mechanically worked interaction for stiffness, immaturity and fineness on Pima S-2 and Lankart 57 (8 modifications).

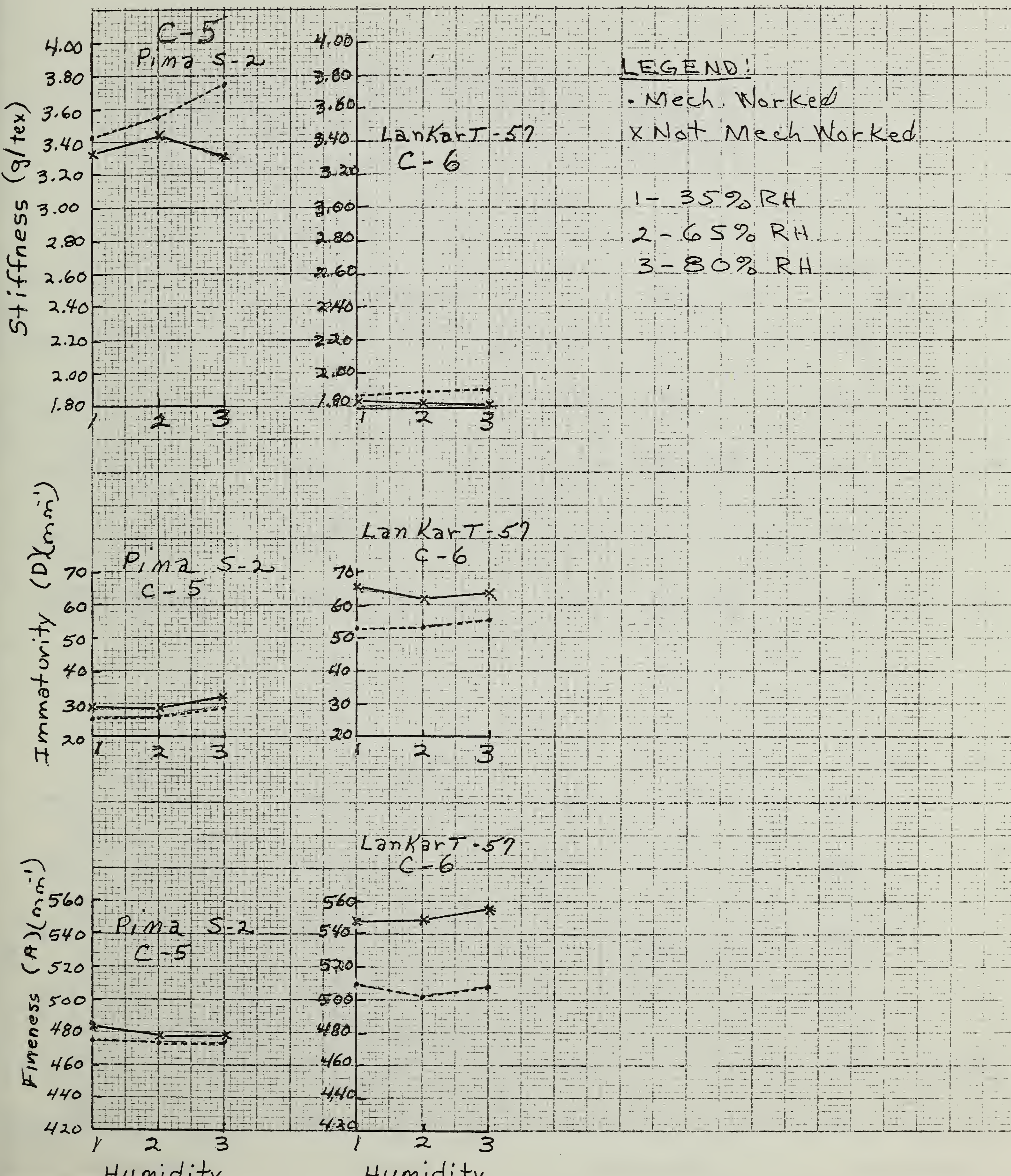


Figure C-18. Humidity-mechanically worked interaction for ACV and length uniformity on Cal 7-8, Deltapine Smooth Leaf, Acala 4-42 and Stoneville 7A (8 modifications).

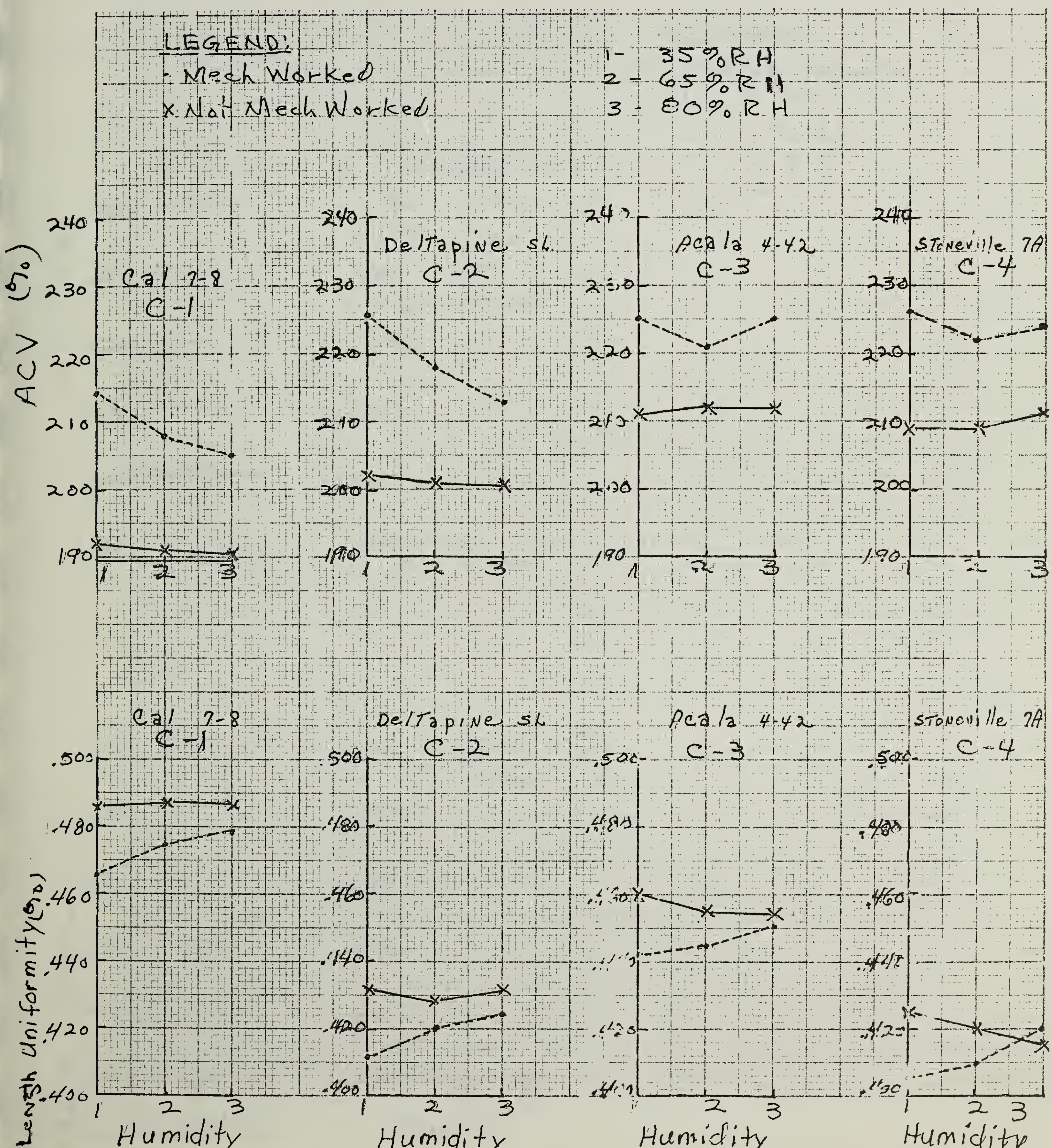


Figure C-19. Humidity-mechanically worked interaction for ACV and length uniformity on Pima S-2 and Lankart 57 (8 modifications).

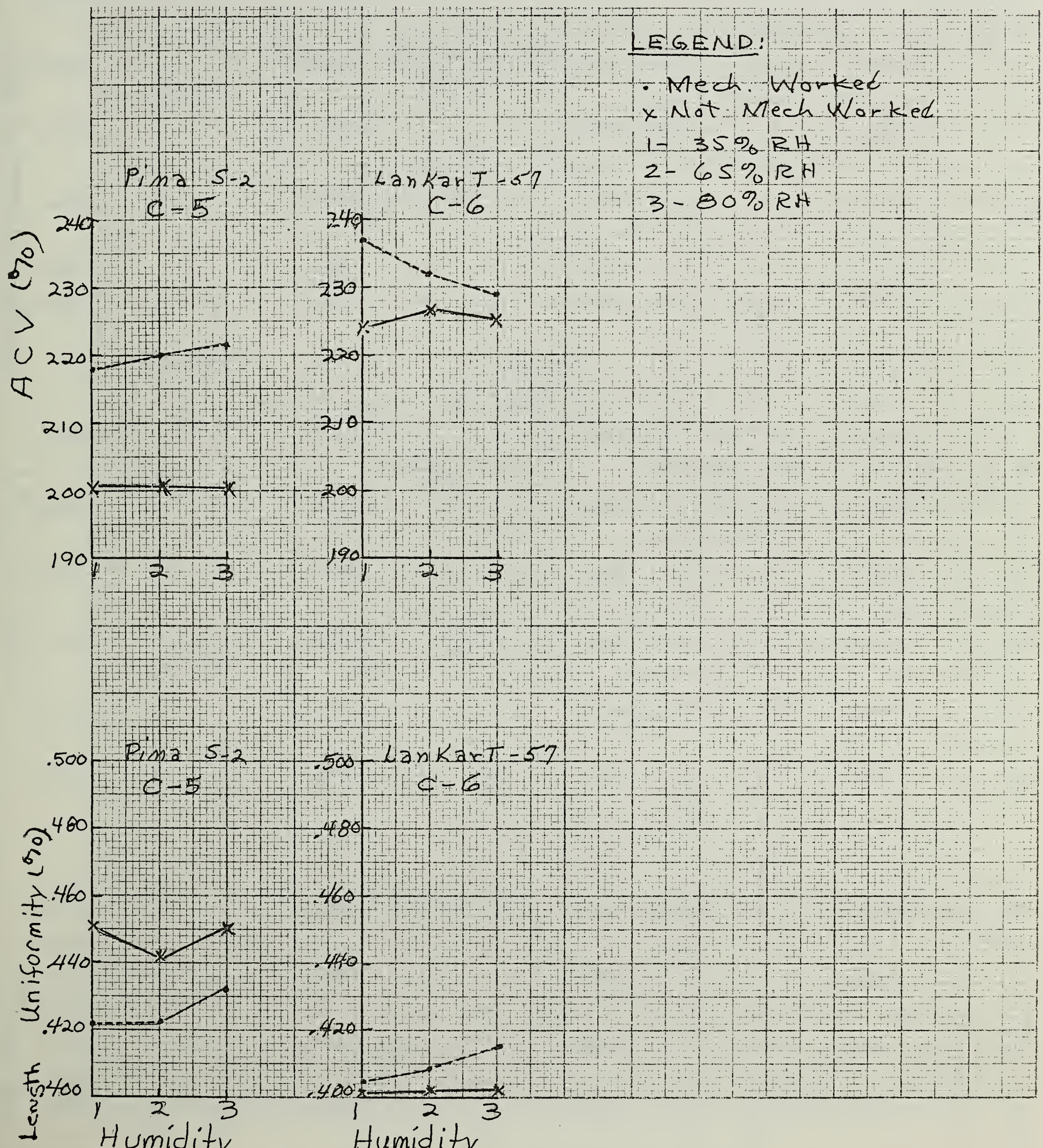


Figure C-20. Humidity-mechanically wowked interaction for length uniformity, 2.5% span length and 50% span length on Cal 7-8, Deltapine Smooth Leaf, Acala 4-42 and Stoneville &A (6 modifications).

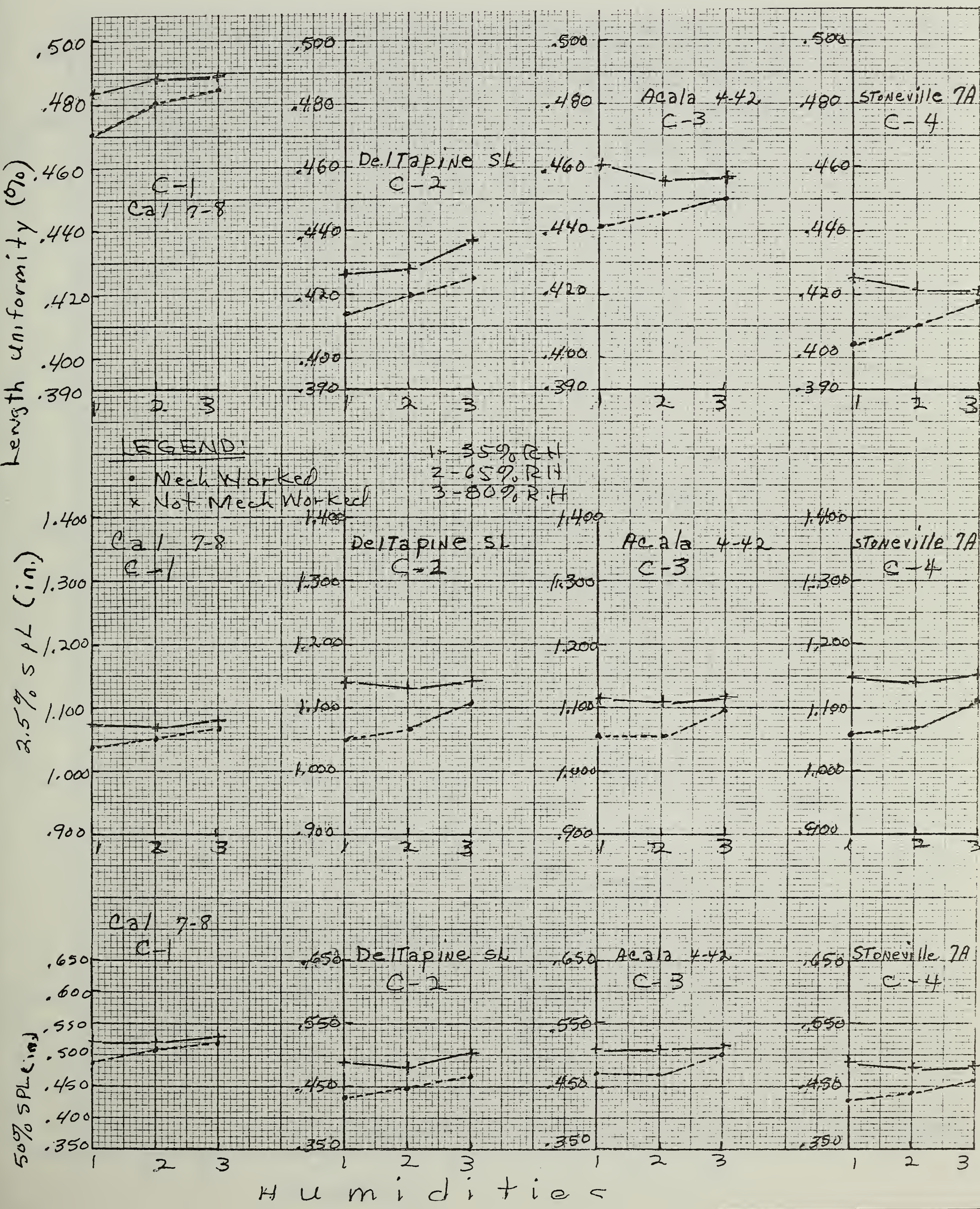


Figure C-21. Humidity-mechanically worked interaction for length uniformity, 2.5% span length, 50% span length, ACV and stiffness on Pima S-2 and Lankart 57 (6 modifications).

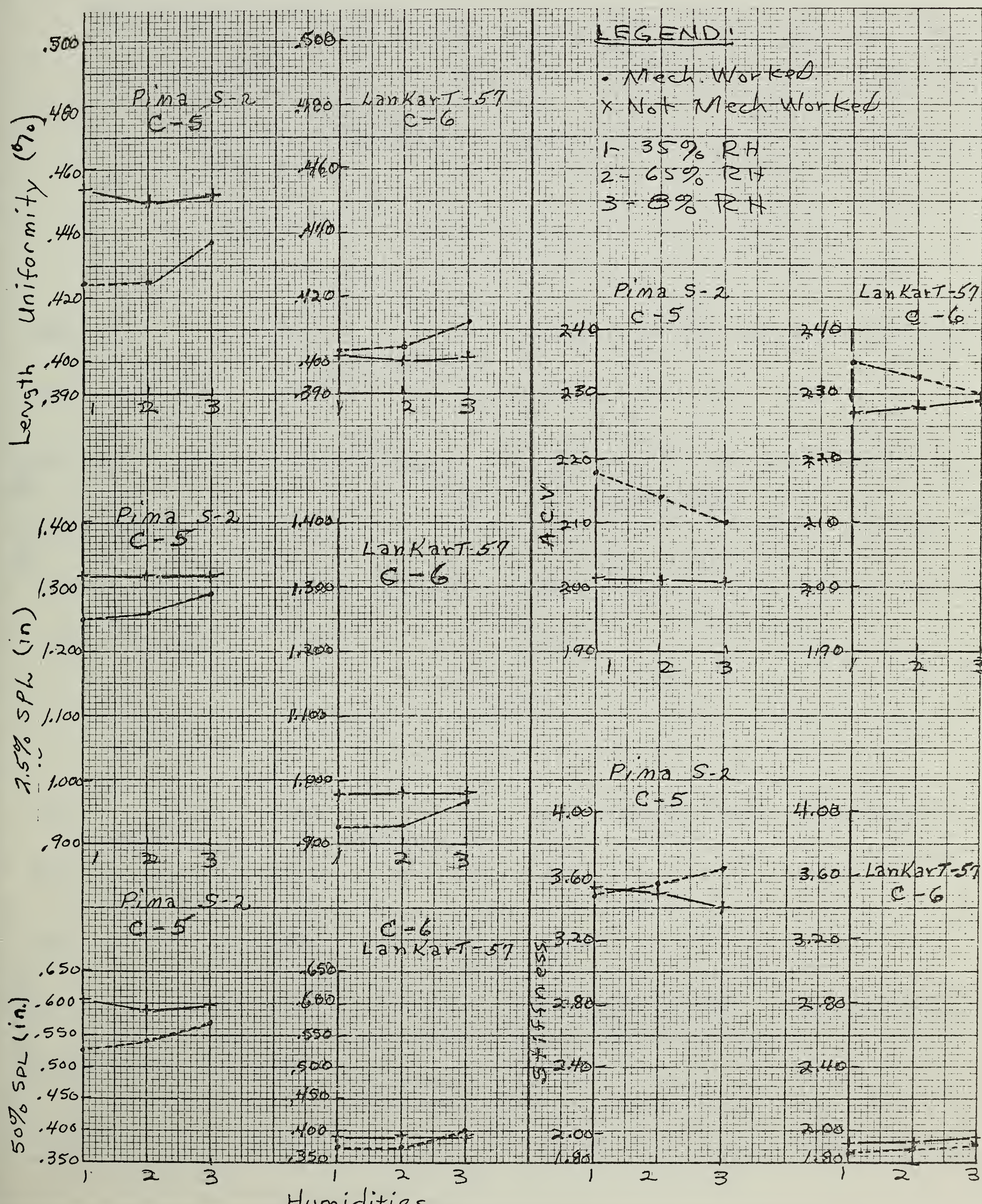
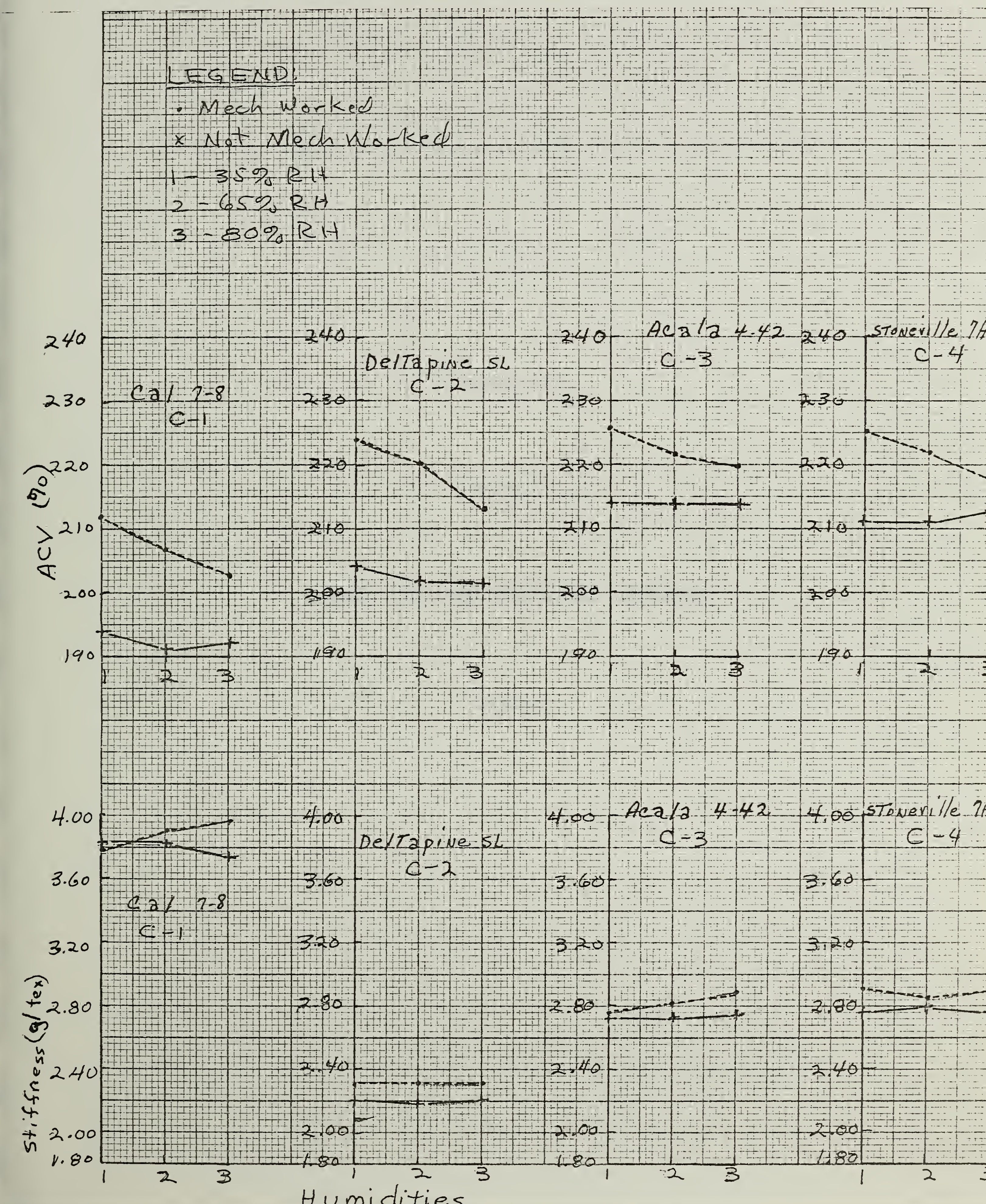


Figure C-22. Humidity-mechanically worked interaction for ACV and stiffness on Cal 7-8, Deltapine Smooth Leaf, Acala 4-42, and Stoneville 7A (6 modifications).



SECTION XII

APPENDIX D

GENERAL DATA FOR MECHANICAL TREATMENTS

(Tables)

TABLE D–I. Fiber Properties on Cal 7-8 (C-1) as Affected by Modifications and Levels of Crushing, Mechanical Working, and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part a. Tenacity 1/8 in. Gauge (g/tex)														
Control	21.9	20.5	20.2	20.7	19.6	19.4	19.8	18.0	19.2	19.6	22.4	21.3	22.7	23.8
35%-72°C	22.4	21.4	21.0	20.3	18.8	19.8	20.1	17.7	19.6	20.5	22.1	22.4	22.6	23.1
65%-72°C	22.0	21.0	20.8	20.6	19.6	19.6	19.5	17.8	19.6	20.2	22.3	21.6	22.4	22.4
80%-72°C	21.8	20.6	20.9	20.3	19.6	20.6	20.4	17.4	20.2	20.0	22.2	22.4	22.9	22.8
35%-180°C	21.1	20.6	20.7	20.2	19.1	19.0	19.1	16.5	18.6	19.4	21.3	21.0	21.4	21.8
65%-180°C	20.8	20.2	20.2	20.0	18.3	19.2	19.6	17.1	18.4	18.7	20.8	21.2	21.1	20.8
Alcohol	22.8	21.0	21.0	20.5	16.4	18.8	19.6	15.6	17.8	19.2	22.6	22.6	23.1	24.6
NaOH	26.5	26.2	25.7	25.7	25.1	25.0	25.2	24.8	25.0	25.4	26.4	25.9	26.1	26.8
Part b. Elongation (%)														
Control	5.7	7.4	7.6	7.6	7.6	8.1	8.1	7.8	8.6	8.4	5.7	5.8	5.7	5.4
35%-72°C	5.6	7.3	7.6	8.0	8.3	8.5	8.2	8.2	8.0	8.0	6.1	5.8	5.6	6.0
65%-72°C	5.4	7.2	7.6	8.2	7.8	8.4	8.5	8.0	8.2	8.8	5.9	5.8	5.8	6.0
80%-72°C	5.7	7.5	7.8	8.2	7.9	8.2	8.2	8.0	7.8	8.4	5.7	5.9	5.8	5.6
35%-180°C	5.6	7.4	7.6	8.3	7.7	7.8	8.0	7.7	8.2	8.4	5.5	5.4	5.6	5.6
65%-180°C	5.5	6.8	7.6	7.6	7.6	7.8	7.8	8.0	8.0	8.2	5.6	5.6	5.4	5.6
Alcohol	5.1	6.5	6.7	7.2	7.1	7.2	7.5	7.2	7.4	7.6	5.1	4.8	5.0	4.5
NaOH	17.1	17.5	18.0	18.2	17.8	18.4	18.0	17.7	19.3	18.3	16.6	15.8	16.5	16.7

[1] Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-I. Fiber Properties on Cal 7-8 (C-1) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part c. Toughness (g/tex)														
Control	0.62	0.76	0.77	0.80	0.74	0.77	0.80	0.70	0.82	0.83	0.64	0.61	0.64	0.64
35%-72°C	0.63	0.78	0.80	0.82	0.78	0.84	0.82	0.72	0.78	0.81	0.68	0.64	0.62	0.68
65%-72°C	0.60	0.76	0.79	0.84	0.76	0.82	0.83	0.72	0.80	0.88	0.65	0.63	0.66	0.68
80%-72°C	0.62	0.78	0.81	0.84	0.77	0.85	0.83	0.69	0.79	0.83	0.63	0.66	0.66	0.66
35%-180°C	0.58	0.76	0.78	0.84	0.74	0.74	0.76	0.64	0.76	0.81	0.59	0.57	0.60	0.60
65%-180°C	0.57	0.69	0.77	0.76	0.70	0.76	0.77	0.68	0.73	0.76	0.58	0.60	0.57	0.58
Alcohol	0.58	0.68	0.70	0.74	0.58	0.68	0.74	0.56	0.66	0.72	0.58	0.54	0.58	0.56
NaOH	2.27	2.29	2.32	2.34	2.22	2.30	2.26	2.19	2.41	2.32	2.18	2.04	2.15	2.24
Part d. Impact Strength (g/tex)														
Control	19.1	18.8	19.2	19.2	18.1	19.4	19.3	16.8	18.8	19.2	19.0	18.6	19.2	20.0
35%-72°C	19.4	19.2	19.0	19.2	18.2	18.8	19.2	16.7	18.4	19.5	19.0	19.0	19.8	20.3
65%-72°C	19.1	19.0	19.1	19.5	18.7	18.4	18.6	16.0	18.7	18.8	18.9	18.3	20.2	19.8
80%-72°C	19.4	18.4	19.0	19.0	18.1	18.8	19.6	16.4	19.2	19.2	18.9	19.4	19.8	19.8
35%-180°C	18.4	18.4	18.2	19.2	17.0	18.0	18.6	15.4	17.5	18.2	18.5	18.0	19.0	19.4
65%-180°C	18.2	18.4	18.4	18.4	16.4	17.8	18.2	15.4	17.0	18.0	18.3	18.5	18.8	18.8
Alcohol	19.5	19.2	19.4	19.3	15.7	17.9	19.3	15.0	17.2	18.8	18.8	17.0	20.2	20.4
NaOH	27.6	26.9	27.4	27.2	26.4	26.9	27.0	26.2	26.2	27.2	27.8	26.8	28.0	28.8

[1]Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-I. Fiber Properties on Cal 7-8 (C-1) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing Control	Crushing Level 1 35%	Level 1 65%	Level 1 80%	Level 2 35%	Level 2 65%	Level 2 80%	Level 3 35%	Level 3 65%	Level 3 80%	Mechanical Working Control	Worked 35%	Worked 65%	Worked 80%
Part e. 50 Per Cent Span Length (in.)														
Control	0.53	0.52	0.54	0.54	0.50	0.53	0.52	0.46	0.52	0.53	0.51	0.48	0.52	0.51
35%-72°C	0.53	0.53	0.52	0.54	0.50	0.54	0.54	0.46	0.49	0.52	0.53	0.50	0.50	0.54
65%-72°C	0.54	0.52	0.53	0.52	0.52	0.52	0.53	0.44	0.52	0.53	0.52	0.50	0.52	0.52
80%-72°C	0.54	0.52	0.54	0.53	0.50	0.52	0.54	0.46	0.50	0.53	0.54	0.50	0.51	0.53
35%-180°C	0.52	0.52	0.53	0.52	0.48	0.51	0.54	0.42	0.49	0.50	0.52	0.46	0.51	0.51
65%-180°C	0.52	0.51	0.52	0.52	0.46	0.49	0.52	0.46	0.48	0.52	0.53	0.50	0.49	0.52
Alcohol	0.52	0.52	0.51	0.54	0.37	0.40	0.45	0.32	0.38	0.44	0.49	0.33	0.38	0.38
NaOH	0.46	0.46	0.45	0.46	0.46	0.46	0.44	0.46	0.46	0.45	0.47	0.46	0.47	0.47
Part f. 2.5 Per Cent Span Length (in.)														
Control	1.07	1.06	1.08	1.07	1.04	1.05	1.06	1.00	1.05	1.04	1.08	1.04	1.06	1.06
35%-72°C	1.07	1.06	1.06	1.06	1.03	1.05	1.06	1.00	1.03	1.06	1.09	1.04	1.04	1.08
65%-72°C	1.07	1.06	1.06	1.06	1.05	1.04	1.05	0.99	1.04	1.06	1.08	1.05	1.06	1.07
80%-72°C	1.07	1.07	1.07	1.06	1.02	1.06	1.06	1.00	1.04	1.05	1.09	1.06	1.06	1.08
35%-180°C	1.07	1.06	1.06	1.06	1.02	1.04	1.06	0.98	1.03	1.04	1.07	1.02	1.06	1.08
65%-180°C	1.06	1.06	1.04	1.06	1.00	1.03	1.04	1.00	1.03	1.05	1.08	1.04	1.05	1.08
Alcohol	1.07	1.05	1.04	1.06	0.92	0.96	1.01	0.85	0.94	1.00	1.06	0.84	0.92	0.92
NaOH	0.93	0.92	0.91	0.92	0.93	0.92	0.91	0.92	0.94	0.91	0.93	0.92	0.92	0.94

[1] Each entry in the crushing and mechanical working control columns is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-I. Fiber Properties on Cal 7-8 (C-1) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
	Part g. Fineness (mm^{-1})													
Control	445	434	435	434	436	438	432	428	430	434	442	442	442	433
35%-72°C	442	434	431	428	432	435	432	432	432	433	442	442	434	436
65%-72°C	443	438	434	433	433	429	426	428	431	432	449	438	434	439
80%-72°C	444	435	431	428	431	437	429	430	431	426	445	441	439	440
35%-180°C	442	434	422	428	436	432	430	434	428	428	444	444	434	432
65%=180°C	446	436	427	432	442	433	431	434	431	430	446	442	444	444
Alcohol	435	426	425	424	418	418	421	412	418	424	440	420	416	415
NaOH	346	352	356	351	354	357	354	360	351	354	345	346	350	352
	Part h. Immaturity (mm^{-1})													
Control	29	16	24	23	22	22	22	22	20	22	29	28	28	30
35%-72°C	28	22	21	19	21	18	24	21	20	26	32	30	28	34
65%-72°C	28	27	18	18	20	18	20	18	19	22	33	23	20	32
80%-72°C	24	18	17	19	19	21	16	19	16	22	29	24	30	30
35%-180°C	22	18	19	23	20	19	22	20	18	22	29	26	26	26
65%-180°C	26	21	26	22	15	20	20	22	17	14	26	24	31	36
Alcohol	17	15	13	12	9	7	8	5	10	16	16	5	7	10
NaOH	9	6	9	9	8	9	6	8	5	7	10	8	11	12

[1]Each entry in the mechanical working control column is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-I. Fiber Properties on Cal 7-8 (C-1) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part i. Alkali Centrifuge Value (%)														
Control	188	194	194	192	196	196	195	199	193	194	192	209	204	200
35%-72°C	188	194	193	194	196	195	194	197	195	193	190	212	207	201
65%-72°C	192	193	192	192	196	194	193	197	194	194	191	210	204	200
80%-72°C	190	193	192	192	196	194	192	194	194	190	192	208	206	201
35%-180°C	196	196	196	195	212	200	198	204	202	196	198	219	210	207
65%-180°C	194	198	197	199	205	203	200	204	202	198	196	214	214	209
Alcohol	188	196	195	193	201	200	198	203	200	196	192	245	228	234
NaOH	182	185	184	184	184	184	186	184	181	182	183	196	193	191

[1] Each entry in the mechanical working control column is a mean of 12 readings. All other entires are the means of 4 readings.

TABLE D-II. Fiber Properties on Deltapine Smooth Leaf (C-2) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part a. Tenacity 1/8 in. Gauge (g/tex)														
Control	19.9	18.8	18.7	18.3	17.6	18.7	18.9	17.4	17.9	18.2	19.8	20.5	20.2	20.2
35%-72°C	19.8	18.4	18.6	18.4	17.8	18.4	18.3	17.2	18.5	18.3	19.6	20.0	20.4	20.2
65%-72°C	19.9	19.0	18.6	18.8	18.0	18.0	18.3	17.1	18.3	18.6	19.6	20.0	20.4	20.4
80%-72°C	19.4	18.6	18.6	18.8	18.3	18.8	18.6	16.8	18.6	18.6	20.0	20.5	20.3	20.8
35%-180°C	18.8	18.8	18.7	18.8	18.0	18.4	18.2	16.4	18.2	18.1	19.4	19.6	20.2	20.2
65%-180°C	19.0	18.6	18.2	17.8	17.3	18.3	18.4	16.0	17.5	18.2	19.3	19.6	20.0	19.9
Alcohol	20.5	19.2	19.2	19.2	16.9	17.8	17.8	14.4	17.0	18.0	20.6	21.2	21.0	20.8
NaOH	20.4	19.6	20.2	19.8	19.6	19.6	20.3	19.6	19.8	19.4	20.7	21.4	21.0	20.8
Part b. Elongation (%)														
Control	9.0	10.3	10.2	10.2	10.0	10.0	10.2	10.4	10.6	11.0	9.1	9.2	9.2	8.7
35%-72°C	9.4	10.9	10.6	10.9	10.3	10.8	11.0	10.4	11.0	10.6	9.0	8.8	8.9	8.8
65%-72°C	8.9	10.2	10.8	10.6	10.2	10.4	10.7	10.0	10.9	10.8	8.9	8.8	8.8	8.6
80%-72°C	8.9	10.0	10.4	10.8	10.4	10.6	10.3	10.6	10.9	11.3	9.2	9.2	9.0	9.0
35%-180°C	8.9	10.0	10.6	10.8	10.8	10.7	11.0	9.8	10.7	11.0	8.7	8.4	8.3	8.6
65%-180°C	8.7	9.8	10.4	10.7	10.6	10.8	10.6	10.0	10.8	11.0	8.7	8.2	8.5	8.5
Alcohol	8.0	9.0	9.8	10.1	9.5	10.4	10.6	9.4	9.8	11.2	7.9	6.8	8.4	7.4
NaOH	18.4	19.2	18.8	18.9	18.7	19.6	19.0	19.8	19.4	19.1	18.1	17.0	17.9	17.6

[1] Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-II. Fiber Properties on Deltapine Smooth Leaf (C-2) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
						Part c. Toughness (g/tex)								
Control	0.90	0.97	0.94	0.94	0.88	0.94	0.97	0.90	0.95	1.00	0.90	0.94	0.93	0.88
35%-72°C	0.92	1.00	0.98	1.00	0.92	1.00	1.01	0.90	1.02	0.96	0.88	0.88	0.91	0.88
65%-72°C	0.88	0.97	1.01	1.00	0.93	0.94	0.98	0.86	1.00	1.02	0.88	0.88	0.90	0.88
80%-72°C	0.86	0.92	0.96	1.02	0.95	0.99	0.96	0.88	1.01	1.05	0.92	0.94	0.92	0.94
35%-180°C	0.84	0.94	0.98	1.01	0.97	0.98	1.00	0.80	0.98	1.00	0.84	0.82	0.84	0.88
65%-180°C	0.82	0.90	0.96	0.95	0.92	0.99	0.98	0.80	0.95	1.00	0.84	0.80	0.84	0.84
Alcohol	0.82	0.86	0.94	0.96	0.82	0.92	0.94	0.68	0.83	1.00	0.82	0.72	0.88	0.80
NaOH	1.87	1.88	1.89	1.86	1.82	1.92	1.92	1.94	1.92	1.85	1.88	1.82	1.88	1.84
						Part d. Impact Strength (g/tex)								
Control	17.2	17.0	16.8	16.6	16.5	17.5	17.4	15.4	16.7	17.1	17.5	17.3	17.6	18.2
35%-72°C	17.1	16.8	17.3	17.5	16.8	16.6	17.0	15.9	16.6	16.8	17.4	16.8	17.6	17.7
65%-72°C	17.2	17.0	17.4	17.4	16.9	17.2	17.3	15.4	18.2	18.2	17.5	17.2	17.5	18.2
80%-72°C	17.7	18.1	17.4	17.4	16.6	17.2	17.5	15.2	17.0	17.2	17.5	17.0	17.4	18.2
35%-180°C	17.0	17.0	16.9	17.0	16.6	16.8	17.0	14.6	16.0	16.0	16.8	16.8	17.0	17.8
65%-180°C	16.5	16.9	16.2	16.6	15.7	16.7	16.4	14.1	16.2	16.2	16.4	17.1	17.0	17.4
Alcohol	17.6	17.4	16.9	18.0	15.6	16.5	16.8	13.2	16.1	16.7	17.2	16.9	18.4	19.4
NaOH	21.0	20.8	20.8	21.0	20.4	19.9	20.6	20.2	20.4	19.9	20.7	20.6	21.4	21.6

[1]Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-II. Fiber Properties on Deltapine Smooth Leaf (C-2) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part e. 50 Per Cent Span Length (in.)														
Control	0.49	0.50	0.50	0.51	0.48	0.51	0.52	0.49	0.52	0.52	0.50	0.45	0.45	0.48
35%-72°C	0.50	0.50	0.52	0.50	0.52	0.51	0.53	0.49	0.50	0.52	0.51	0.45	0.46	0.47
65%-72°C	0.50	0.51	0.52	0.52	0.51	0.50	0.52	0.48	0.52	0.50	0.50	0.44	0.46	0.48
80%-72°C	0.50	0.51	0.52	0.52	0.50	0.52	0.52	0.46	0.51	0.52	0.49	0.42	0.45	0.48
35%-180°C	0.48	0.50	0.51	0.52	0.49	0.50	0.52	0.43	0.50	0.50	0.48	0.42	0.43	0.48
65%-180°C	0.49	0.50	0.51	0.48	0.48	0.51	0.51	0.44	0.48	0.50	0.48	0.42	0.43	0.46
Alcohol	0.47	0.51	0.50	0.51	0.43	0.44	0.48	0.34	0.44	0.49	0.46	0.30	0.40	0.41
NaOH	0.45	0.48	0.46	0.46	0.44	0.46	0.46	0.46	0.46	0.46	0.45	0.41	0.43	0.45
Part f. 2.5 Per Cent Span Length (in.)														
Control	1.14	1.14	1.14	1.12	1.12	1.14	1.15	1.12	1.14	1.15	1.14	1.07	1.07	1.12
35%-72°C	1.14	1.14	1.15	1.14	1.14	1.14	1.15	1.12	1.13	1.15	1.14	1.07	1.09	1.10
65%-72°C	1.13	1.14	1.14	1.15	1.13	1.14	1.14	1.10	1.14	1.14	1.14	1.06	1.09	1.12
80%-72°C	1.14	1.14	1.15	1.15	1.13	1.16	1.14	1.09	1.14	1.14	1.14	1.05	1.08	1.12
35%-180°C	1.13	1.14	1.14	1.15	1.13	1.14	1.14	1.06	1.12	1.12	1.13	1.06	1.05	1.10
65%-180°C	1.13	1.12	1.12	1.12	1.10	1.13	1.12	1.07	1.10	1.12	1.13	1.04	1.06	1.11
Alcohol	1.12	1.13	1.13	1.13	1.04	1.05	1.09	0.93	1.06	1.10	1.11	0.77	1.00	1.02
NaOH	0.99	1.00	0.98	0.99	0.98	0.98	1.00	0.99	0.99	1.00	0.99	0.96	0.98	1.00

[1]Each entry in the crushing and mechanical working control columns is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-II. Fiber Properties on Deltapine Smooth Leaf (C-2) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
					Part g. Fineness (mm^{-1})									
Control	448	436	435	432	432	434	430	434	434	436	457	453	454	452
35%-72°C	446	442	432	440	430	438	434	440	432	434	459	448	450	452
65%-72°C	448	438	440	439	438	437	434	436	430	428	458	450	448	451
80%-72°C	454	442	436	427	444	441	441	438	439	441	460	452	453	457
35%-180°C	457	445	438	442	438	440	435	440	436	431	458	448	451	452
65%-180°C	452	443	440	435	437	438	436	436	436	432	460	456	444	452
Alcohol	438	434	431	430	428	426	427	426	429	424	446	444	451	440
NaOH	340	342	344	340	344	344	346	349	349	345	338	340	339	344
					Part h. Immaturity (mm^{-1})									
Control	32	28	24	26	32	27	28	26	30	27	37	34	36	36
35%-72°C	27	36	33	26	27	30	26	28	28	30	36	37	39	38
65%-72°C	34	26	27	30	27	31	25	23	30	32	33	36	32	34
80%-72°C	34	21	30	31	29	24	31	28	32	26	36	31	42	40
35%-180°C	34	30	25	30	31	30	21	25	21	25	30	32	38	43
65%-180°C	35	32	32	28	28	26	26	29	30	26	33	26	30	40
Alcohol	21	25	14	22	11	25	18	16	22	19	23	10	30	26
NaOH	8	6	8	6	4	10	9	8	8	5	7	8	8	9

[1]Each entry in the mechanical working control column is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-II. Fiber Properties on Deltapine Smooth Leaf (C-2) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing: Control	Level 1: 35%	Level 1: 65%	Level 1: 80%	Level 2: 35%	Level 2: 65%	Level 2: 80%	Level 3: 35%	Level 3: 65%	Level 3: 80%	Mechanical Working: Control	Worked: 35%	Worked: 65%	Worked: 80%
Part i. Alkali Centrifuge Value (%)														
Control	202	206	205	204	210	206	207	212	215	213	201	218	216	212
35%-72°C	206	217	210	210	221	215	212	223	218	220	202	224	214	208
65%-72°C	214	216	220	220	210	206	204	212	208	205	201	220	220	213
80%-72°C	201	206	204	202	210	209	204	210	206	206	202	222	220	211
35%-180°C	213	215	216	216	221	218	214	221	216	211	207	231	230	220
65%-180°C	212	215	214	210	219	216	216	223	215	214	206	233	225	220
Alcohol	202	211	208	209	215	213	212	220	210	209	204	260	223	225
NaOH	192	200	190	192	188	193	193	192	193	190	193	202	201	198

[1]Each entry in the mechanical working control column is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-III. Fiber Properties on Acala 4-42 (C-3) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part a. Tenacity 1/8 in. (g/tex)														
Control	20.8	20.5	19.8	20.0	19.0	19.5	20.2	17.6	19.4	20.4	21.4	21.2	21.4	22.0
35%-72°C	20.8	20.1	20.0	20.2	19.0	19.7	19.9	18.2	19.6	19.6	21.2	21.5	21.3	22.0
65%-72°C	20.9	19.8	20.8	20.0	19.0	19.7	20.4	18.8	19.6	19.7	21.3	21.2	21.0	21.2
80%-72°C	20.9	20.1	19.5	19.6	19.1	19.7	19.4	17.6	19.7	19.8	21.0	21.0	21.5	21.6
35%-180°C	20.1	19.4	19.8	20.0	18.8	19.0	19.8	17.4	19.0	19.6	19.9	20.2	20.8	20.8
65%-180°C	20.4	19.0	19.4	19.2	19.0	19.0	19.6	17.2	18.8	20.1	20.0	19.9	20.5	20.5
Alcohol	22.1	21.2	20.8	20.8	17.6	18.8	19.8	15.2	17.2	19.9	22.1	21.6	22.1	25.7
NaOH	25.0	24.1	24.0	24.8	23.8	24.3	24.1	24.2	24.6	24.4	24.6	24.4	24.2	24.8
Part b. Elongation (%)														
Control	7.6	8.9	9.3	9.6	9.4	9.2	10.1	9.2	9.4	9.4	7.5	7.6	7.6	7.2
35%-72°C	7.4	8.9	9.4	9.8	9.3	9.6	9.8	9.5	9.4	9.6	7.6	7.4	7.4	7.4
65%-72°C	7.5	9.2	9.4	9.6	9.2	9.6	9.8	9.3	10.0	10.0	7.4	7.6	7.4	7.8
80%-72°C	7.6	9.4	9.7	9.7	9.4	9.8	9.9	9.4	9.8	8.8	7.6	7.6	7.5	7.4
35%-180°C	7.2	9.2	9.0	9.3	9.2	9.4	9.4	8.6	9.4	9.6	7.4	7.4	7.4	7.6
65%-180°C	7.1	8.6	9.2	9.4	9.0	9.4	9.6	9.0	9.6	9.6	7.3	7.2	7.5	7.2
Alcohol	6.6	7.6	8.5	8.0	8.2	8.4	8.8	8.6	9.2	8.9	6.5	6.3	6.3	5.0
NaOH	18.6	19.8	19.8	19.6	20.1	20.0	20.1	19.6	20.0	20.0	18.2	17.9	19.0	18.0

[1]Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-III. Fiber Properties on Acala 4-42 (C-3) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
						Part c. Toughness (g/tex)								
Control	0.79	0.91	0.92	0.96	0.90	0.90	1.02	0.82	0.91	0.96	0.80	0.80	0.82	0.80
35%-72°C	0.77	0.90	0.93	1.00	0.88	0.94	0.98	0.86	0.92	0.94	0.80	0.80	0.78	0.81
65%-72°C	0.78	0.91	0.98	0.96	0.88	0.94	1.00	0.87	0.98	0.98	0.79	0.80	0.78	0.82
80%-72°C	0.79	0.94	0.95	0.94	0.90	0.96	0.96	0.88	0.97	0.87	0.80	0.80	0.80	0.80
35%-180°C	0.72	0.88	0.88	0.93	0.87	0.88	0.94	0.75	0.90	0.94	0.74	0.74	0.77	0.78
65%-180°C	0.72	0.82	0.88	0.90	0.85	0.90	0.94	0.78	0.90	0.96	0.73	0.72	0.76	0.74
Alcohol	0.72	0.80	0.88	0.83	0.72	0.80	0.86	0.65	0.80	0.88	0.72	0.68	0.69	0.64
NaOH	2.32	23.8	2.37	2.42	2.39	2.44	2.42	2.38	2.46	2.44	2.24	2.18	2.28	2.23
						Part d. Impact Strength (g/tex)								
Control	18.0	18.6	18.2	18.8	17.0	17.8	18.6	16.2	18.4	18.5	18.2	18.5	18.6	19.0
35%-72°C	18.1	18.0	18.2	18.2	16.4	18.0	18.4	16.4	18.0	18.4	18.1	18.5	18.8	18.8
65%-72°C	18.2	18.4	17.6	18.2	17.2	18.4	18.6	16.2	18.3	18.2	18.3	18.1	18.0	19.1
80%-72°C	18.1	18.0	18.6	18.8	17.8	18.4	18.5	15.8	18.6	16.8	17.8	17.8	18.7	18.8
35%-180°C	17.1	17.4	17.6	18.4	16.8	17.8	17.7	15.1	16.7	17.8	16.9	17.2	17.6	18.4
65%-180°C	17.2	17.0	18.2	17.6	16.8	17.4	17.6	15.4	17.4	17.8	17.2	17.0	17.4	18.2
Alcohol	19.0	19.2	18.6	18.9	15.0	17.4	18.6	13.2	16.3	18.2	18.6	17.0	18.4	19.6
NaOH	25.8	25.6	25.1	24.6	24.9	24.8	25.2	25.2	25.2	24.4	25.8	25.4	25.7	26.6

[1]Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-III. Fiber Properties on Acala 4-42 (C-3) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modifi-	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
cation		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part e. 50 Per Cent Span Length (in.)														
Control	0.52	0.52	0.53	0.52	0.50	0.51	0.53	0.47	0.52	0.52	0.52	0.48	0.48	0.52
35%-72°C	0.52	0.52	0.54	0.52	0.50	0.50	0.51	0.47	0.52	0.53	0.51	0.47	0.50	0.51
65%-72°C	0.52	0.52	0.52	0.53	0.50	0.52	0.50	0.46	0.51	0.53	0.52	0.47	0.47	0.51
80%-72°C	0.52	0.50	0.52	0.52	0.50	0.52	0.52	0.46	0.52	0.54	0.51	0.48	0.48	0.50
35%-180°C	0.50	0.51	0.50	0.52	0.48	0.51	0.50	0.44	0.48	0.52	0.51	0.46	0.44	0.48
65%-180°C	0.50	0.50	0.51	0.50	0.50	0.50	0.50	0.42	0.51	0.53	0.50	0.47	0.46	0.49
Alcohol	0.48	0.50	0.50	0.52	0.38	0.44	0.48	0.32	0.38	0.44	0.46	0.38	0.41	0.30
NaOH	0.46	0.46	0.45	0.46	0.46	0.47	0.46	0.46	0.47	0.46	0.46	0.45	0.46	0.46
Part f. 2.5 Per Cent Span Length (in.)														
Control	1.10	1.10	1.10	1.11	1.08	1.10	1.10	1.06	1.11	1.10	1.12	1.08	1.06	1.11
35%-72°C	1.11	1.10	1.11	1.11	1.08	1.09	1.09	1.06	1.10	1.11	1.11	1.06	1.08	1.10
65%-72°C	1.10	1.10	1.11	1.11	1.08	1.10	1.10	1.05	1.08	1.10	1.12	1.06	1.06	1.12
80%-72°C	1.11	1.10	1.10	1.10	1.08	1.10	1.10	1.05	1.11	1.11	1.11	1.08	1.08	1.10
35%-180°C	1.10	1.10	1.10	1.10	1.08	1.10	1.09	1.04	1.07	1.10	1.11	1.06	1.04	1.08
65%-180°C	1.10	1.10	1.10	1.10	1.07	1.08	1.10	1.01	1.10	1.10	1.11	1.06	1.05	1.09
Alcohol	1.09	1.09	1.09	1.10	0.97	1.03	1.04	0.88	0.98	1.06	1.08	0.96	0.99	0.73
NaOH	0.96	0.96	0.95	0.96	0.96	0.96	0.96	0.94	0.96	0.95	0.95	0.94	0.94	0.96

[1]Each entry in the crushing and mechanical working control columns is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-III. Fiber Properties on Acala 4-42 (C-3) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modifi-cation	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
					Part g. Fineness (mm^{-1})									
Control	518	499	488	486	491	486	488	493	494	487	522	518	504	502
35%-72°C	523	504	492	490	488	488	486	492	486	478	519	513	497	509
65%-72°C	513	496	495	487	495	496	491	488	488	492	518	515	507	506
80%-72°C	512	492	488	488	492	485	487	488	492	485	518	508	510	508
35%-180°C	521	494	490	490	497	494	484	492	486	490	525	510	502	510
65%-180°C	514	500	494	490	489	480	487	492	493	486	524	508	510	507
Alcohol	512	500	487	479	478	484	478	474	474	472	512	490	492	471
NaOH	382	392	379	380	381	387	382	386	386	386	379	374	380	376
					Part h. Immaturity (mm^{-1})									
Control	48	47	46	42	40	44	48	48	46	46	53	52	56	56
35%-72°C	56	50	52	46	48	41	46	44	45	51	57	50	54	53
65%-72°C	52	46	48	48	47	38	40	46	49	52	54	48	56	54
80%-72°C	51	56	48	44	42	43	45	43	45	46	52	54	54	56
35%-180°C	56	46	41	42	43	40	44	42	50	44	55	52	48	59
65%-180°C	50	46	43	44	48	46	52	46	44	46	55	53	53	62
Alcohol	38	40	42	35	29	28	27	32	28	31	40	39	32	18
NaOH	14	16	18	14	19	13	13	13	13	16	10	6	11	12

[1]Each entry in the mechanical working control column is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-III . Fiber Properties on Acala 4-42 (C-3) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
							Part i. Alkali Centrifuge Value (%)							
Control	210	213	212	212	216	214	214	216	216	212	211	224	224	216
35%-72°C	216	214	214	212	213	214	211	215	212	210	213	224	216	220
65%-72°C	208	215	214	212	219	216	212	216	212	213	213	224	221	218
80%-72°C	208	213	213	212	218	216	214	216	214	213	215	222	221	220
35%-180°C	212	218	214	213	220	216	214	218	216	210	217	231	223	226
65%-180°C	212	214	216	213	216	216	212	217	215	214	215	232	231	224
Alcohol	205	212	212	213	214	214	216	221	212	212	207	234	225	270
NaOH	197	203	198	198	198	202	200	202	202	200	207	210	208	211

[1]Each entry in the mechanical working control column is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-IV. Fiber Properties on Stoneville 7A (C-4) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing Control	Crushing Level 1 35%	Crushing Level 1 65%	Crushing Level 1 80%	Crushing Level 2 35%	Crushing Level 2 65%	Crushing Level 2 80%	Crushing Level 3 35%	Crushing Level 3 65%	Crushing Level 3 80%	Mechanical Working Control	Mechanical Working Worked 35%	Mechanical Working Worked 65%	Mechanical Working Worked 80%
Part a. Tenacity 1/8 in. Gauge (g/tex)														
Control	18.3	17.3	17.2	17.5	16.8	17.2	16.8	16.4	17.2	17.6	18.6	19.4	19.0	19.3
35%-72°C	18.4	18.2	18.2	18.0	17.8	17.8	18.2	17.0	17.9	17.8	18.6	19.2	19.0	19.8
65%-72°C	18.5	17.9	18.4	17.8	17.4	17.6	17.4	16.0	17.5	17.5	18.6	19.0	18.8	18.9
80%-82°C	18.4	17.7	17.4	17.7	17.2	17.3	17.4	16.0	17.8	18.0	18.5	19.2	19.0	19.2
35%-180°C	17.8	17.8	17.7	17.2	17.0	17.6	17.6	15.6	16.6	17.4	17.8	18.2	17.8	18.2
65%-180°C	17.6	17.2	17.2	17.8	16.8	17.1	17.5	15.6	16.4	17.4	18.1	17.6	18.1	18.9
Alcohol	19.4	18.2	18.0	18.8	16.4	18.4	18.0	14.0	16.9	17.4	19.5	19.5	19.0	22.4
NaOH	20.2	20.5	20.6	19.9	20.2	20.2	20.2	19.6	19.8	20.0	21.2	21.5	20.9	21.4
Part b. Elongation (%)														
Control	6.7	8.1	8.8	8.8	8.5	9.1	9.4	8.5	8.4	9.2	6.5	6.5	6.6	6.4
35%-72°C	6.7	8.1	8.2	8.6	8.5	8.5	9.0	8.6	8.6	8.6	6.6	6.4	6.6	6.5
65%-72°C	6.7	8.0	8.3	8.8	8.8	8.5	9.0	8.8	8.8	8.8	6.6	6.7	6.6	6.4
80%-72°C	6.7	8.4	8.6	8.6	8.9	8.4	8.4	8.5	8.6	8.6	6.7	6.4	6.4	6.6
35%-180°C	6.4	7.4	8.5	8.4	8.3	8.6	8.1	8.8	8.8	8.6	6.7	6.4	6.5	6.5
65%-180°C	6.5	8.0	8.4	8.6	8.2	8.6	8.2	8.7	8.4	8.8	6.4	6.4	6.5	6.4
Alcohol	6.2	7.5	7.5	8.0	7.6	7.8	8.4	8.0	8.4	8.5	6.1	6.0	6.3	5.2
NaOH	16.9	17.1	16.8	17.6	17.6	17.4	17.4	17.8	17.7	17.2	16.2	15.6	16.2	16.2

[1] Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-IV. Fiber Properties on Stoneville 7A (C-4) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
	Part c. Toughness (g/tex)													
Control	0.61	0.70	0.75	0.77	0.72	0.78	0.79	0.70	0.73	0.80	0.61	0.63	0.62	0.64
35%-72°C	0.61	0.74	0.75	0.77	0.76	0.76	0.82	0.73	0.77	0.77	0.61	0.61	0.64	0.64
65%-72°C	0.62	0.72	0.76	0.79	0.76	0.75	0.78	0.70	0.76	0.78	0.61	0.64	0.62	0.60
80%-72°C	0.61	0.74	0.75	0.77	0.76	0.72	0.73	0.68	0.76	0.77	0.62	0.61	0.62	0.63
35%-180°C	0.57	0.66	0.75	0.72	0.70	0.75	0.72	0.68	0.72	0.75	0.60	0.58	0.58	0.58
65%-180°C	0.58	0.68	0.72	0.76	0.68	0.73	0.72	0.68	0.70	0.76	0.58	0.56	0.59	0.60
Alcohol	0.60	0.68	0.68	0.76	0.62	0.72	0.76	0.56	0.71	0.74	0.60	0.58	0.60	0.58
NaOH	1.71	1.76	1.74	1.75	1.78	1.74	1.76	1.74	1.75	1.72	1.72	1.68	1.69	1.74
	Part d. Impact Strength (g/tex)													
Control	15.4	15.5	15.8	15.8	15.4	15.8	16.0	14.9	16.0	16.0	15.2	15.2	15.6	15.7
35%-72°C	15.6	15.8	16.2	16.6	16.2	16.4	16.0	15.0	16.0	16.4	15.4	15.8	16.0	16.2
65%-72°C	15.2	15.6	16.0	15.6	15.6	15.9	15.6	14.4	15.4	15.7	15.1	14.8	15.6	16.0
80%-72°C	15.3	15.1	15.4	16.1	15.5	15.8	16.6	14.1	15.6	15.8	15.4	14.6	15.8	16.2
35%-180°C	14.7	15.6	15.8	15.4	15.2	15.8	15.6	13.3	15.0	15.6	14.6	13.9	14.6	15.6
65%-180°C	14.9	15.2	16.0	15.8	14.9	15.6	15.9	14.0	14.8	15.9	15.1	14.6	15.8	15.4
Alcohol	15.8	16.2	16.4	17.1	14.6	15.4	16.2	12.4	15.0	16.3	15.8	15.4	16.2	16.6
NaOH	20.7	20.6	20.2	20.5	20.2	21.2	20.4	20.8	20.4	20.6	21.2	20.3	20.8	22.1

[1]Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-IV. Fiber Properties on Stoneville 7A (C-4) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part e. 50 Per Cent Span Length (in.)														
Control	0.48	0.50	0.50	0.52	0.50	0.50	0.52	0.50	0.52	0.51	0.49	0.44	0.45	0.48
35%-72°C	0.49	0.52	0.51	0.51	0.50	0.52	0.52	0.49	0.49	0.52	0.50	0.45	0.44	0.47
65%-72°C	0.48	0.50	0.49	0.50	0.48	0.49	0.50	0.46	0.48	0.49	0.49	0.44	0.44	0.46
80%-82°C	0.48	0.50	0.51	0.50	0.49	0.50	0.50	0.45	0.48	0.50	0.50	0.44	0.45	0.46
35%-180°C	0.47	0.49	0.50	0.50	0.50	0.50	0.50	0.44	0.49	0.50	0.47	0.41	0.43	0.46
65%-180°C	0.48	0.48	0.50	0.49	0.47	0.49	0.50	0.44	0.47	0.48	0.49	0.41	0.42	0.46
Alcohol	0.45	0.52	0.50	0.49	0.40	0.44	0.48	0.32	0.42	0.45	0.42	0.30	0.39	0.28
NaOH	0.44	0.45	0.44	0.44	0.45	0.45	0.44	0.44	0.45	0.44	0.44	0.41	0.42	0.44
Part f. 2.5 Per Cent Span Length (in.)														
Control	1.14	1.14	1.15	1.15	1.13	1.13	1.15	1.12	1.13	1.14	1.16	1.07	1.09	1.14
35%-72°C	1.14	1.15	1.15	1.14	1.14	1.14	1.14	1.12	1.13	1.15	1.16	1.09	1.08	1.12
65%-72°C	1.14	1.13	1.14	1.14	1.13	1.14	1.13	1.10	1.13	1.14	1.15	1.08	1.08	1.11
80%-72°C	1.14	1.13	1.15	1.15	1.12	1.14	1.14	1.10	1.12	1.14	1.16	1.07	1.07	1.12
35%-180°C	1.13	1.12	1.14	1.13	1.12	1.14	1.13	1.06	1.12	1.13	1.14	1.05	1.06	1.10
65%-180°C	1.13	1.14	1.14	1.12	1.10	1.12	1.14	1.07	1.11	1.13	1.14	1.04	1.05	1.10
Alcohol	1.11	1.14	1.12	1.14	1.02	1.08	1.12	0.90	1.06	1.09	1.09	0.79	0.98	0.69
NaOH	0.99	0.98	0.98	0.98	0.98	0.98	0.98	0.98	1.00	0.98	0.99	0.96	0.98	0.98

[1] Each entry in the crushing and mechanical working control columns is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-IV. Fiber Properties on Stoneville 7A (C-4) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part g. Fineness (mm^{-1})														
Control	488	481	474	466	470	465	466	472	458	458	496	484	484	478
35%-72°C	492	478	476	467	468	473	472	468	464	468	496	484	484	486
65%-72°C	496	476	466	462	471	466	463	472	465	460	501	483	490	476
80%-72°C	486	471	471	464	462	458	462	462	466	466	498	481	482	482
35%-180°C	494	470	471	472	466	468	461	466	468	470	499	486	482	484
65%-180°C	490	476	466	458	458	459	460	464	463	464	504	484	488	485
Alcohol	474	467	456	453	463	460	452	451	452	454	484	469	466	454
NaOH	350	358	358	358	358	360	361	361	362	357	361	355	359	351
Part h. Immaturity (mm^{-1})														
Control	46	50	42	44	34	40	40	39	37	30	48	46	47	48
35%-72°C	49	43	44	39	42	42	43	40	42	45	48	41	42	50
65%-72°C	56	45	41	38	42	41	40	45	42	44	48	42	50	48
80%-72°C	48	38	39	44	40	36	39	42	39	36	46	35	42	44
35%-180°C	49	40	43	41	44	40	39	36	38	37	48	44	42	44
65%-180°C	50	38	40	34	36	36	44	38	43	32	46	42	49	48
Alcohol	34	30	34	28	29	33	26	24	26	23	36	17	22	14
NaOH	4	6	8	12	10	12	8	12	8	9	12	6	10	12

[1]The mechanical working control is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D–IV. Fiber Properties on Stoneville 7A (C-4) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
					Part i. Alkali Centrifuge Value (%)									
Control	213	215	215	214	216	215	215	220	213	212	212	224	222	217
35%-72°C	212	216	216	214	222	219	219	222	218	218	214	224	222	219
65%-72°C	216	217	215	214	220	218	220	222	216	214	213	224	220	214
80%-82°C	208	216	220	214	218	218	215	219	216	218	210	221	221	216
35%-180°C	216	216	219	215	219	220	215	218	218	218	212	230	224	222
65%-180°C	214	219	215	215	222	219	217	225	222	219	213	230	228	222
Alcohol	210	214	214	213	216	215	212	214	216	213	210	250	232	277
NaOH	201	200	202	200	210	199	200	198	198	195	199	206	206	206

[1]Each entry in the mechanical working control is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-V. Fiber Properties on Pima S-2 (C-5) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part a. Tenacity 1/8 in. Gauge (g/tex)														
Control	29.7	27.8	27.6	27.0	26.4	27.2	26.6	24.4	26.9	26.6	29.2	29.4	29.8	30.4
35%-72°C	29.4	27.2	27.6	26.5	25.8	27.0	27.4	24.6	26.0	27.2	29.1	28.4	30.2	29.5
65%-72°C	28.8	27.2	27.2	27.7	24.4	26.4	26.9	24.8	27.0	26.9	28.9	29.0	28.6	29.2
80%-72°C	29.4	28.0	28.2	26.6	27.4	28.0	28.0	24.7	26.9	27.6	28.6	28.4	29.4	29.1
35%-180°C	27.6	26.8	26.0	26.6	24.9	25.8	26.0	23.5	26.0	26.2	27.6	27.0	27.8	29.0
65%-180°C	28.4	26.9	26.8	27.6	25.6	26.8	27.5	24.2	26.5	26.7	28.0	27.3	28.4	27.4
Alcohol	30.0	29.0	28.0	28.4	24.6	26.4	26.4	21.0	26.1	26.0	30.1	29.8	30.6	32.0
NaOH	28.9	28.8	28.4	28.0	28.9	28.4	27.9	28.4	29.2	28.3	28.8	28.0	28.6	28.8
Part b. Elongation (%)														
Control	7.9	9.6	9.2	9.9	9.2	9.7	10.0	9.5	9.8	9.8	8.1	8.2	8.3	7.8
35%-72°C	8.2	9.6	9.4	10.2	9.5	9.8	10.2	9.9	10.0	9.9	8.2	7.8	8.2	8.0
65%-72°C	8.3	9.4	9.8	9.8	9.6	9.9	9.8	9.6	9.5	10.0	8.3	8.1	8.2	8.1
80%-72°C	8.1	8.8	9.2	9.4	9.4	9.3	9.2	9.6	9.6	10.0	8.3	8.4	8.3	8.2
35%-180°C	7.9	8.7	9.6	9.6	9.4	9.6	9.6	9.3	9.5	9.6	8.2	7.8	8.0	7.8
65%-180°C	7.8	8.8	9.2	9.0	9.0	9.2	9.5	9.2	9.6	9.8	7.8	7.9	8.0	7.6
Alcohol	7.3	8.1	8.8	8.0	8.4	8.4	8.5	9.1	8.8	9.2	7.1	6.6	5.8	5.2
NaOH	18.2	19.6	20.1	19.6	18.4	19.4	18.5	17.6	18.8	18.7	18.0	17.0	15.8	15.4

[1] Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-V. Fiber Properties on Pima S-2 (C-5) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part c. Toughness (g/tex)														
Control	1.17	1.32	1.28	1.34	1.21	1.32	1.32	1.16	1.32	1.32	1.18	1.20	1.24	1.18
35%-72°C	1.20	1.30	1.29	1.36	1.22	1.32	1.39	1.22	1.30	1.34	1.19	1.10	1.23	1.18
65%-72°C	1.20	1.28	1.34	1.36	1.18	1.30	1.32	1.18	1.28	1.35	1.19	1.17	1.16	1.18
80%-72°C	1.20	1.24	1.30	1.26	1.28	1.30	1.29	1.18	1.29	1.38	1.19	1.20	1.22	1.20
35%-180°C	1.09	1.18	1.24	1.27	1.17	1.24	1.24	1.10	1.23	1.25	1.13	1.06	1.10	1.12
65%-180°C	1.11	1.18	1.24	1.24	1.16	1.22	1.30	1.12	1.28	1.32	1.09	1.08	1.13	1.04
Alcohol	1.10	1.17	1.22	1.13	1.03	1.10	1.12	0.95	1.14	1.20	1.07	0.99	0.89	0.84
NaOH	2.63	2.82	2.86	2.74	2.66	2.76	2.58	2.50	2.74	2.65	2.58	2.38	2.24	2.21
Part d. Impact Strength (g/tex)														
Control	26.9	26.4	26.0	26.2	24.3	26.3	26.3	22.8	25.6	25.6	26.1	26.2	26.6	28.0
35%-72°C	26.4	25.6	26.6	25.9	24.7	26.6	26.7	22.9	25.8	26.0	26.7	25.6	27.3	26.4
65%-72°C	26.9	26.4	26.3	26.6	23.6	26.0	25.8	23.0	25.4	25.6	26.0	26.0	27.2	27.6
80%-72°C	26.5	26.5	27.1	26.0	25.8	26.2	26.0	23.2	25.6	26.2	25.8	25.6	26.4	26.8
35%-180°C	24.9	25.2	25.4	25.2	23.5	24.2	24.6	21.8	24.5	24.8	24.9	24.4	25.6	26.4
65%-180°C	26.0	25.4	25.4	26.4	24.0	25.6	25.8	22.7	23.7	25.0	25.5	24.4	25.4	25.2
Alcohol	27.5	26.1	25.8	26.0	22.1	23.5	25.2	18.5	24.8	24.8	27.1	26.1	24.7	23.8
NaOH	31.0	30.2	29.0	29.7	29.5	27.4	29.7	27.9	29.4	30.0	29.9	29.0	29.6	30.6

[1]Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-V. Fiber Properties on Pima S-2 (C-5) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part e. 50 Per Cent Span Length (in.)														
Control	0.60	0.60	0.61	0.58	0.57	0.60	0.60	0.54	0.60	0.60	0.60	0.54	0.56	0.60
35%-72°C	0.60	0.60	0.60	0.61	0.58	0.59	0.61	0.52	0.60	0.60	0.60	0.54	0.55	0.57
65%-72°C	0.60	0.60	0.62	0.60	0.56	0.60	0.60	0.53	0.57	0.60	0.61	0.54	0.55	0.57
80%-72°C	0.60	0.60	0.61	0.62	0.58	0.60	0.62	0.54	0.58	0.59	0.61	0.54	0.54	0.60
35%-180°C	0.58	0.58	0.59	0.59	0.58	0.59	0.58	0.52	0.57	0.59	0.59	0.52	0.53	0.54
65%-180°C	0.58	0.58	0.58	0.60	0.56	0.59	0.59	0.53	0.56	0.58	0.59	0.51	0.52	0.54
Alcohol	0.58	0.60	0.58	0.60	0.42	0.48	0.52	0.39	0.48	0.50	0.55	0.43	0.34	0.28
NaOH	0.52	0.51	0.52	0.51	0.52	0.53	0.50	0.52	0.51	0.50	0.51	0.48	0.48	0.50
Part f. 2.5 Per Span Length (in.)														
Control	1.34	1.32	1.32	1.32	1.30	1.32	1.32	1.28	1.32	1.32	1.33	1.27	1.28	1.32
35%-72°C	1.32	1.32	1.32	1.32	1.28	1.32	1.32	1.27	1.32	1.32	1.32	1.26	1.28	1.30
65%-72°C	1.33	1.32	1.32	1.33	1.28	1.31	1.32	1.25	1.30	1.32	1.32	1.26	1.26	1.30
80%-72°C	1.33	1.33	1.33	1.33	1.30	1.31	1.34	1.26	1.30	1.32	1.33	1.26	1.28	1.30
35%-180°C	1.31	1.30	1.30	1.32	1.28	1.32	1.30	1.25	1.29	1.31	1.32	1.22	1.26	1.30
65%-180°C	1.32	1.30	1.30	1.32	1.28	1.30	1.30	1.26	1.28	1.30	1.32	1.24	1.25	1.26
Alcohol	1.32	1.30	1.30	1.31	1.14	1.21	1.25	1.01	1.20	1.22	1.29	1.13	0.87	0.72
NaOH	1.15	1.14	1.14	1.14	1.14	1.16	1.14	1.14	1.13	1.14	1.13	1.10	1.10	1.15

[1]Each entry in the crushing and mechanical working control columns is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-V. Fiber Properties on Pima S-2 (C-5) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part g. Fineness (mm^{-1})														
Control	514	495	494	491	496	496	500	496	500	502	496	492	490	494
35%-72°C	505	494	500	498	484	488	496	485	490	495	505	494	500	481
65%-72°C	490	490	492	498	492	502	496	498	490	496	502	494	487	494
80%-72°C	504	496	494	488	495	497	494	496	497	494	496	494	497	483
35%-180°C	506	498	502	496	488	494	488	499	498	496	497	490	489	504
65%-180°C	498	496	492	495	494	494	498	494	500	495	500	489	488	494
Alcohol	500	490	498	490	481	485	485	480	487	483	499	486	471	478
NaOH	388	388	396	391	402	392	399	395	404	396	379	378	384	386
Part h. Immaturity (mm^{-1})														
Control	31	35	27	26	32	28	30	28	25	32	31	32	34	42
35%-72°C	29	28	34	30	34	31	31	36	33	32	31	36	35	38
65%-72°C	43	40	40	37	30	32	32	32	29	32	33	27	36	35
80%-72°C	37	36	32	32	33	42	32	30	33	31	38	30	38	41
35%-180°C	32	34	30	32	36	34	32	32	36	36	33	32	42	44
65%-180°C	35	38	36	27	32	32	36	30	28	39	32	33	36	40
Alcohol	26	25	30	21	20	24	14	14	21	17	23	16	6	14
NaOH	5	2	6	11	10	6	10	8	8	10	9	6	12	10

[1]Each entry in the mechanical working control column is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-V. Fiber Properties on Pima S-2 (C-5) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part i. Alkali Centrifuge Value (%)														
Control	205	206	204	202	210	206	207	210	207	202	198	219	210	209
35%-72°C	200	204	208	204	209	206	204	210	206	203	199	216	210	206
65%-72°C	198	204	204	204	210	208	205	213	207	207	197	214	212	204
80%-72°C	202	208	206	202	212	204	202	210	205	202	198	214	210	210
35%-180°C	208	214	212	211	215	214	212	220	217	214	208	227	222	216
65%-180°C	207	214	213	209	218	218	212	218	216	213	209	222	223	222
Alcohol	200	207	210	205	212	208	208	210	212	210	200	234	272	302
NaOH	191	192	190	192	194	196	194	194	197	194	194	204	203	200

[1] Each entry in the mechanical working control column is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-VI. Fiber Properties on Lankart 57 (C-6) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part a. Tenacity 1/8 in. Gauge (g/tex)														
Control	16.5	16.6	16.6	16.5	15.7	16.8	16.4	15.4	16.4	16.8	17.2	17.4	17.3	17.8
35%-72°C	16.6	16.6	16.2	16.6	16.2	16.2	16.0	14.8	16.6	16.5	16.9	17.3	17.4	17.2
65%-72°C	16.6	16.1	16.4	16.1	14.9	15.6	15.8	14.2	15.4	15.8	16.8	17.2	16.8	17.3
80%-72°C	16.8	16.1	16.3	15.9	15.4	15.4	15.4	14.8	15.5	15.8	17.1	16.6	17.5	17.2
35%-180°C	16.8	16.0	15.7	16.0	14.8	15.6	15.8	14.4	15.4	15.4	16.1	15.8	16.4	16.6
65%-180°C	16.6	15.4	16.0	15.4	15.0	15.7	15.2	13.6	15.2	16.0	16.1	15.6	16.0	16.5
Alcohol	18.6	17.0	16.8	17.0	14.2	15.6	16.0	12.2	14.8	15.8	18.4	18.6	18.5	18.6
NaOH	19.0	18.8	18.1	18.8	18.3	18.2	18.4	17.8	18.4	18.2	18.9	18.8	19.3	19.2
Part b. Elongation (%)														
Control	9.0	9.6	10.6	10.8	10.0	10.9	10.7	10.7	11.0	11.4	8.9	8.8	8.9	8.6
35%-72°C	9.1	10.6	11.0	11.0	10.8	10.8	11.4	11.1	11.0	11.0	8.6	8.4	8.4	8.5
65%-72°C	8.9	10.8	10.9	11.1	11.0	11.6	11.6	11.0	10.9	11.6	9.5	8.6	9.4	8.9
80%-72°C	9.1	10.4	11.0	11.3	10.9	11.8	11.8	10.8	11.4	11.8	9.5	9.5	9.2	9.2
35%-180°C	9.2	10.0	10.8	10.9	11.0	10.8	10.8	10.7	11.0	10.8	9.2	9.3	9.0	9.0
65%-180°C	9.0	10.5	10.4	11.0	10.8	10.9	11.5	11.0	11.6	11.0	8.9	9.1	9.2	8.7
Alcohol	8.0	9.0	9.6	9.5	9.8	10.0	10.0	9.2	9.6	9.2	7.8	7.2	7.4	7.6
NaOH	18.2	18.5	19.4	19.4	18.6	19.2	19.0	19.2	19.4	19.9	17.6	17.6	18.4	18.4

[1] Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-VI. Fiber Properties on Lankart 57 (C-6) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part c. Toughness (g/tex)														
Control	0.74	0.80	0.87	0.90	0.78	0.92	0.88	0.82	0.90	0.96	0.76	0.76	0.77	0.77
35%-72°C	0.75	0.88	0.88	0.92	0.86	0.88	0.92	0.82	0.92	0.91	0.73	0.72	0.74	0.73
65%-72°C	0.74	0.86	0.90	0.89	0.82	0.91	0.92	0.78	0.84	0.92	0.80	0.74	0.80	0.77
80%-72°C	0.77	0.82	0.90	0.90	0.84	0.91	0.90	0.80	0.88	0.92	0.81	0.78	0.80	0.80
35%-180°C	0.78	0.80	0.85	0.87	0.81	0.84	0.86	0.78	0.85	0.83	0.74	0.73	0.74	0.74
65%-180°C	0.75	0.81	0.83	0.85	0.80	0.86	0.88	0.74	0.88	0.88	0.72	0.71	0.74	0.72
Alcohol	0.74	0.76	0.80	0.81	0.70	0.78	0.80	0.58	0.72	0.72	0.72	0.67	0.68	0.70
NaOH	1.73	1.74	1.76	1.82	1.70	1.76	1.74	1.76	1.82	1.80	1.66	1.66	1.78	1.76
Part d. Impact Strength (g/tex)														
Control	14.9	14.9	15.5	15.2	14.6	15.4	15.0	13.6	14.8	14.9	15.1	15.6	15.0	15.6
35%-72°C	15.2	14.6	15.0	15.5	14.8	15.2	15.0	13.6	14.8	15.2	15.1	14.6	15.0	15.4
65%-72°C	15.2	15.0	15.2	15.4	14.4	15.1	15.0	12.7	14.6	14.8	14.8	14.4	15.4	16.0
80%-72°C	15.2	15.0	15.1	15.2	14.0	14.6	15.1	13.7	14.8	15.4	15.1	14.4	14.3	15.7
35%-180°C	14.5	15.0	14.9	15.2	14.2	14.8	14.9	13.2	14.0	14.9	14.8	14.0	15.4	15.2
65%-180°C	14.6	14.5	15.3	15.0	14.0	14.4	14.8	13.0	14.3	14.9	14.2	14.0	14.4	15.3
Alcohol	15.2	15.2	15.6	15.8	12.6	14.4	14.8	11.3	13.4	14.2	15.3	14.0	15.0	16.4
NaOH	19.0	18.4	18.2	18.8	18.4	18.5	18.2	18.2	18.0	18.8	19.1	18.6	19.4	19.6

[1]Each entry in the crushing and mechanical working control columns is a mean of 24 readings. All other entries are the means of 8 readings.

TABLE D-VI. Fiber Properties on Lankart 57 (C-6) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part e. 50 Per Cent Span Length (in.)														
Control	0.40	0.40	0.41	0.40	0.38	0.41	0.40	0.39	0.41	0.41	0.40	0.38	0.38	0.40
35%-72°C	0.41	0.41	0.41	0.42	0.41	0.41	0.42	0.38	0.42	0.41	0.39	0.37	0.36	0.40
65%-72°C	0.40	0.40	0.41	0.42	0.40	0.43	0.43	0.38	0.41	0.41	0.40	0.39	0.39	0.40
80%-72°C	0.40	0.42	0.42	0.42	0.40	0.42	0.42	0.38	0.41	0.42	0.40	0.39	0.38	0.41
35%-180°C	0.40	0.42	0.40	0.42	0.40	0.40	0.41	0.36	0.40	0.40	0.39	0.37	0.38	0.40
65%-180°C	0.39	0.41	0.41	0.42	0.40	0.41	0.40	0.38	0.41	0.43	0.38	0.37	0.36	0.38
Alcohol	0.36	0.40	0.41	0.39	0.35	0.37	0.40	0.30	0.34	0.36	0.35	0.26	0.33	0.36
NaOH	0.38	0.38	0.38	0.38	0.39	0.38	0.38	0.38	0.38	0.38	0.37	0.36	0.38	0.39
Part f. 2.5 Per Cent Span Length (in.)														
Control	0.98	0.98	0.98	0.98	0.95	0.98	0.98	0.94	0.98	0.96	0.98	0.94	0.94	0.98
35%-72°C	0.98	0.99	0.98	0.98	0.98	0.98	0.98	0.95	0.98	0.98	0.98	0.93	0.93	0.97
65%-72°C	0.98	0.99	0.99	0.98	0.97	0.99	1.00	0.96	0.98	0.99	0.98	0.94	0.95	0.97
80%-72°C	0.98	0.98	1.00	0.99	0.98	0.97	1.00	0.94	0.98	1.00	0.98	0.93	0.92	0.98
35%-180°C	0.98	0.98	0.98	1.00	0.96	0.97	0.99	0.94	0.96	0.98	0.98	0.93	0.93	0.96
65%-180°C	0.97	0.98	0.98	0.99	0.96	0.98	0.97	0.92	0.97	0.99	0.98	0.93	0.91	0.97
Alcohol	0.94	0.97	0.98	0.96	0.86	0.91	0.96	0.78	0.88	0.92	0.94	0.68	0.82	0.88
NaOH	0.86	0.86	0.87	0.87	0.86	0.87	0.86	0.86	0.87	0.86	0.85	0.84	0.84	0.87

[1]Each entry in the crushing and mechanical working control columns is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-VI. Fiber Properties on Lankart 57 (C-6) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part g. Fineness (mm^{-1})														
Control	564	540	524	518	534	515	522	528	514	518	574	532	542	531
35%-72°C	570	536	526	514	522	524	521	516	510	525	576	534	526	525
65%-72°C	566	533	526	526	520	512	515	520	516	517	576	532	526	528
80%-72°C	565	532	518	522	516	526	515	522	513	526	574	546	518	527
35%-180°C	574	533	518	528	528	525	526	522	522	522	582	535	514	524
65%-180°C	567	538	525	526	524	515	522	524	515	525	576	536	527	534
Alcohol	552	524	514	509	502	506	503	500	491	496	558	493	490	503
NaOH	408	395	394	394	396	394	396	397	395	392	395	380	382	389
Part h. Immaturity (mm^{-1})														
Control	80	57	52	60	58	61	58	58	66	54	72	64	64	60
35%-72°C	74	66	56	60	53	56	54	52	58	56	76	60	58	64
65%-72°C	74	65	60	58	58	56	58	54	54	52	73	62	70	60
80%-72°C	74	67	56	58	58	56	52	54	57	54	74	66	58	70
35%-180°C	72	58	62	52	60	56	52	53	58	56	74	72	56	66
65%-180°C	66	62	57	52	52	56	56	56	51	56	71	58	62	68
Alcohol	63	45	41	46	40	38	35	34	36	34	58	32	32	38
NaOH	15	12	16	17	16	17	23	18	16	14	16	17	18	16

[1]Each entry in the mechanical working control column is a mean of 12 readings. All other entries are the means of 4 readings.

TABLE D-VI. Fiber Properties on Lankart 57 (C-6) as Affected by Modifications and Levels of Crushing, Mechanical Working and Humidities[1]

Modification	Crushing										Mechanical Working			
	Control	Level 1			Level 2			Level 3			Control	Worked		
		35%	65%	80%	35%	65%	80%	35%	65%	80%		35%	65%	80%
Part i. Alkali Centrifuge Value (%)														
Control	226	228	228	228	236	229	228	234	229	228	227	234	234	230
35%-72°C	228	228	232	227	232	230	229	232	228	234	230	235	232	229
65%-72°C	238	235	234	233	242	240	234	236	238	235	229	234	232	227
80%-72°C	233	239	238	225	227	225	223	230	226	227	230	237	231	230
35%-180°C	222	226	224	227	231	235	228	234	231	229	229	240	236	232
65%-180°C	226	230	232	228	232	231	228	232	234	230	225	234	235	234
Alcohol	219	222	224	219	220	233	224	224	223	225	223	264	244	241
NaOH	214	212	221	212	216	210	208	210	205	210	209	218	215	210

[1]Each entry in the mechanical working control column is a mean of 12 readings. All other entries are the means of 4 readings.

SECTION XIII

APPENDIX E

FIBER PROCESSING

(Tables and Graphs)

TABLE E-I. Duncan's Multiple Range Comparison of the Effect of Processing on Tenacity at the 5% Level of Significance

		Modification			
		Control	65%-180°C	Alcohol	NaOH
Variety	Cal 7-8	22.00 B	19.70 B	23.40 B	25.78 A
	Deltapine SL	19.90 C	18.70 B	21.63 B	19.95 B
	Pima S-2	28.50 A	26.17 A	30.85 A	27.43 A
Processing Stage	Unprocessed	23.48 A	21.73 A	25.55 A	24.72 A
	Second Drawing	23.52 A	21.38 A	24.73 B	24.37 A
	At Spinning	23.40 A	21.43 A	25.60 A	24.08 A

		Variety		
		Cal 7-8	Deltapine Smooth Leaf	Pima S-2
Modification	Control	22.00 C	19.90 B	28.50 B
	65%-180°C	19.70 D	18.70 C	26.17 D
	Alcohol	23.40 B	21.63 A	30.85 A
	NaOH	25.78 A	19.95 B	27.43 C
Processing Stage	Unprocessed	22.64 A	20.15 A	28.82 A
	Second Drawing	22.66 A	20.10 A	27.74 B
	At Spinning	22.86 A	19.89 A	28.15 B

		Processing Stage		
		Unprocessed	Second Drawing	At Spinning
Modification	Control	23.48 C	23.52 B	23.40 C
	65%-180°C	21.73 D	21.38 C	21.45 D
	Alcohol	25.55 A	24.73 A	25.60 A
	NaOH	24.72 B	24.37 A	24.08 B
Variety	Cal 7-8	22.64 B	22.66 B	22.86 B
	Deltapine Smooth Leaf	20.15 C	20.10 C	19.89 C
	Pima S-2	28.82 A	27.74 A	28.15 A

Note: The Duncan's range comparison is with respect to the columns only.

TABLE E-II. Duncan's Multiple Range Comparison of the Effect of Processing on Elongation at the 5% Level of Significance

		Modification			
		Control	65%-180°C	Alcohol	NaOH
Variety	Cal 7-8	5.95 B	5.55 B	5.45 B	18.62 A
	Deltapine SL	9.07 A	8.58 A	7.50 A	18.58 A
	Pima S-2	8.83 A	8.37 A	7.12 A	18.97 A
Processing Stage	Unprocessed	7.88 A	7.23 B	6.77 A	18.43 B
	Second Drawing	7.88 A	7.60 AB	6.78 A	19.05 A
	At Spinning	8.08 A	7.67 A	6.52 A	18.68 AB

		Variety		
		Cal 7-8	Deltapine Smooth Leaf	Pima S-2
Modification	Control	5.95 B	9.07 B	8.83 B
	65%-180°C	5.55 C	8.58 C	8.37 C
	Alcohol	5.45 C	7.50 D	7.12 D
	NaOH	18.62 A	18.58 A	18.97 A
Processing Stage	Unprocessed	8.88 A	10.51 B	10.85 A
	Second Drawing	8.91 A	11.16 A	10.91 A
	At Spinning	8.89 A	11.12 A	10.70 A

		Processing Stage		
		Unprocessed	Second Drawing	At Spinning
Modification	Control	7.88 B	7.88 B	8.08 B
	65%-180°C	7.23 C	7.60 B	7.67 C
	Alcohol	6.77 D	6.78 C	6.52 D
	NaOH	18.43 A	19.05 A	18.68 A
Variety	Cal 7-8	8.88 B	8.91 B	8.89 B
	Deltapine SL	10.51 A	11.16 A	11.12 A
	Pima S-2	10.85 A	10.91 A	10.70 A

Note: The Duncan's range comparison is with respect to the columns only.

TABLE E-III. Duncan's Multiple Range Comparison of the Effect of Processing on Toughness at the 5% Level of Significance

		Modification			
		Control	65%-180°C	Alcohol	NaOH
Variety	Cal 7-8	0.655 C	0.547 C	0.637 C	2.400 B
	Deltapine SL	0.903 B	0.803 B	0.805 B	1.855 C
	Pima S-2	1.258 A	1.095 A	1.097 A	2.575 A
Processing Stage	Unprocessed	0.938 A	0.800 A	0.870 A	2.280 A
	Second Drawing	0.930 A	0.820 A	0.842 A	2.297 A
	At Spinning	0.948 A	0.825 A	0.827 A	2.253 A

		Variety		
		Cal 7-8	Deltapine Smooth Leaf	Pima S-2
Modification	Control	0.655 B	0.903 B	1.258 B
	65%-180°C	0.547 C	0.803 C	1.095 C
	Alcohol	0.637 B	0.805 C	1.097 C
	NaOH	2.400 A	1.855 A	2.575 A
Processing Stage	Unprocessed	1.057 A	1.060 B	1.549 A
	Second Drawing	1.062 A	1.120 A	1.484 B
	At Spinning	1.059 A	1.095 AB	1.486 B

		Processing Stage		
		Unprocessed	Second Drawing	At Spinning
Modification	Control	0.938 B	0.930 B	0.948 B
	65%-180°C	0.800 D	0.820 C	0.825 C
	Alcohol	0.870 C	0.842 C	0.827 C
	NaOH	2.280 A	2.297 A	2.253 A
Variety	Cal 7-8	1.057 B	1.062 B	1.059 B
	Deltapine SL	1.060 B	1.120 B	1.095 B
	Pima S-2	1.549 A	1.484 A	1.486 A

Note: The Duncan's range comparison is with respect to the columns only.

TABLE E-IV. Duncan's Multiple Range Comparison of the Effect of Processing on 50% Span Length at the 5% Level of Significance

		Modification			
		Control	65%-180°C	Alcohol	NaOH
Variety	Cal 7-8	0.537 B	0.510 B	0.433 A	0.475 B
	Deltapine SL	0.490 C	0.473 C	0.362 B	0.463 B
	Pima S-2	0.613 A	0.565 A	0.447 A	0.537 A
Processing Stage	Unprocessed	0.547 A	0.522 A	0.412 A	0.490 A
	Second Drawing	0.547 A	0.510 A	0.423 A	0.490 A
	At Spinning	0.547 A	0.517 A	0.407 A	0.495 A

		Variety		
		Cal 7-8	Deltapine Smooth Leaf	Pima S-2
Modification	Control	0.537 A	0.490 A	0.613 A
	65%-180°C	0.510 B	0.473 B	0.565 B
	Alcohol	0.433 D	0.362 C	0.447 D
	NaOH	0.475 C	0.463 B	0.537 C
Processing Stage	Unprocessed	0.482 A	0.452 A	0.542 A
	Second Drawing	0.491 A	0.445 A	0.541 A
	At Spinning	0.492 A	0.444 A	0.537 A

		Processing Stage		
		Unprocessed	Second Drawing	At Spinning
Modification	Control	0.547 A	0.548 A	0.547 A
	65%-180°C	0.522 B	0.510 B	0.517 B
	Alcohol	0.412 D	0.423 D	0.407 D
	NaOH	0.490 C	0.490 C	0.495 C
Variety	Cal 7-8	0.482 B	0.491 B	0.492 B
	Deltapine SL	0.452 C	0.445 C	0.444 C
	Pima S-2	0.542 A	0.541 A	0.537 A

Note: The Duncan's range comparison is with respect to the columns only.

TABLE E-V. Duncan's Multiple Range Comparison of the Effect of Processing on 2.5% Span Length at the 5% Level of Significance

		Modification			
		Control	65%-180°C	Alcohol	NaOH
Variety	Cal 7-8	1.092 B	1.075 B	1.013 B	0.955 B
	Deltapine SL	1.130 B	1.120 B	0.967 B	1.008 B
	Pima S-2	1.323 A	1.302 A	1.182 A	1.173 A
Processing Stage	Unprocessed	1.180 A	1.167 A	1.082 A	1.037 A
	Second Drawing	1.182 A	1.163 A	1.057 B	1.055 A
	At Spinning	1.183 A	1.167 A	1.023 C	1.045 A

		Variety		
		Cal 7-8	Deltapine Smooth Leaf	Pima S-2
Modification	Control	1.092 A	1.130 A	1.323 A
	65%-180°C	1.075 A	1.120 A	1.302 B
	Alcohol	1.013 B	0.967 C	1.182 C
	NaOH	0.955 C	1.008 B	1.173 C
Processing Stage	Unprocessed	1.027 A	1.071 A	1.250 A
	Second Drawing	1.035 A	1.055 B	1.252 A
	At Spinning	1.039 A	1.042 B	1.232 B

		Processing Stage		
		Unprocessed	Second Drawing	At Spinning
Modification	Control	1.180 A	1.182 A	1.183 A
	65%-180°C	1.167 A	1.163 B	1.167 A
	Alcohol	1.082 B	1.057 C	1.023 C
	NaOH	1.037 C	1.055 C	1.045 B
Variety	Cal 7-8	1.027 B	1.035 B	1.039 B
	Deltapine SL	1.071 B	1.055 B	1.042 B
	Pima S-2	1.250 A	1.252 A	1.232 A

Note: The Duncan's range comparison is with respect to the columns only.

TABLE E-VI. Duncan's Multiple Range Comparison of the Effect of Processing on Length Uniformity at the 5% Level of Significance

		Modification			
		Control	65%-180°C	Alcohol	NaOH
Variety	Cal 7-8	49.2 A	47.5 A	42.8 A	49.7 A
	Deltapine SL	43.5 C	42.2 C	37.3 B	46.0 B
	Pima S-2	46.2 B	43.3 B	37.7 B	46.0 B
Processing Stage	Unprocessed	46.3 A	44.8 A	38.2 B	47.5 A
	Second Drawing	46.3 A	43.8 A	40.0 A	46.5 A
	At Spinning	46.2 A	44.3 A	39.7 A	47.7 A

		Variety		
		Cal 7-8	Deltapine Smooth Leaf	Pima S-2
Modification	Control	49.2 A	43.5 B	46.2 A
	65%-180°C	47.5 B	42.2 C	43.3 B
	Alcohol	42.8 C	37.3 D	37.7 C
	NaOH	49.7 A	46.0 A	46.0 A
Processing Stage	Unprocessed	47.0 A	42.2 A	43.3 A
	Second Drawing	47.5 A	42.0 A	43.0 A
	At Spinning	47.4 A	42.5 A	43.5 A

		Processing Stage		
		Unprocessed	Second Drawing	At Spinning
Modification	Control	46.3 A	46.3 A	46.2 B
	65%-180°C	44.8 B	43.8 B	44.3 C
	Alcohol	38.2 C	40.0 C	39.7 D
	NaOH	47.5 A	46.5 A	47.7 A
Variety	Cal 7-8	47.0 A	47.5 A	47.4 A
	Deltapine SL	42.2 C	42.0 C	42.5 C
	Pima S-2	43.3 B	43.0 B	43.5 B

Note: The Duncan's range comparison is with respect to the columns only.

TABLE E-VII. Duncan's Multiple Range Comparison of the Effect of Processing on ACV at the 5% Level of Significance

		Modification			
		Control	65%-180°C	Alcohol	NaOH
Variety	Cal 7-8	193.0 B	203.3 B	207.5 B	181.3 B
	Deltapine SL	204.2 A	213.2 A	226.3 A	188.5 AB
	Pima S-2	205.8 A	219.5 A	222.5 A	191.7 A
Processing Stage	Unprocessed	194.0 C	208.8 B	206.8 B	183.7 B
	Second Drawing	202.2 B	211.7 AB	226.2 A	188.0 A
	At Spinning	206.8 A	215.5 A	223.3 A	189.9 A

		Variety		
		Cal 7-8	Deltapine Smooth Leaf	Pima S-2
Modification	Control	193.0 B	204.2 C	205.8 B
	65%-180°C	203.3 A	213.2 B	219.5 A
	Alcohol	207.5 A	226.3 A	222.5 A
	NaOH	181.3 C	188.5 D	191.7 C
Processing Stage	Unprocessed	190.5 B	202.0 B	202.5 B
	Second Drawing	198.6 A	210.2 A	212.1 A
	At Spinning	199.8 A	211.9 A	215.0 A

		Processing Stage		
		Unprocessed	Second Drawing	At Spinning
Modification	Control	194.0 B	202.2 C	206.8 C
	65%-180°C	208.8 A	211.7 B	215.5 B
	Alcohol	206.8 A	226.2 A	223.3 A
	NaOH	183.7 C	188.0 D	189.8 D
Variety	Cal 7-8	190.5 B	198.6 B	199.8 B
	Deltapine SL	202.0 A	210.2 A	211.9 A
	Pima S-2	202.5 A	212.1 A	215.0 A

Note: The Duncan's range comparison is with respect to the columns only.

Figure E-1. Variety-processing stage interaction as determined by toughness, stiffness, tenacity and elongation.

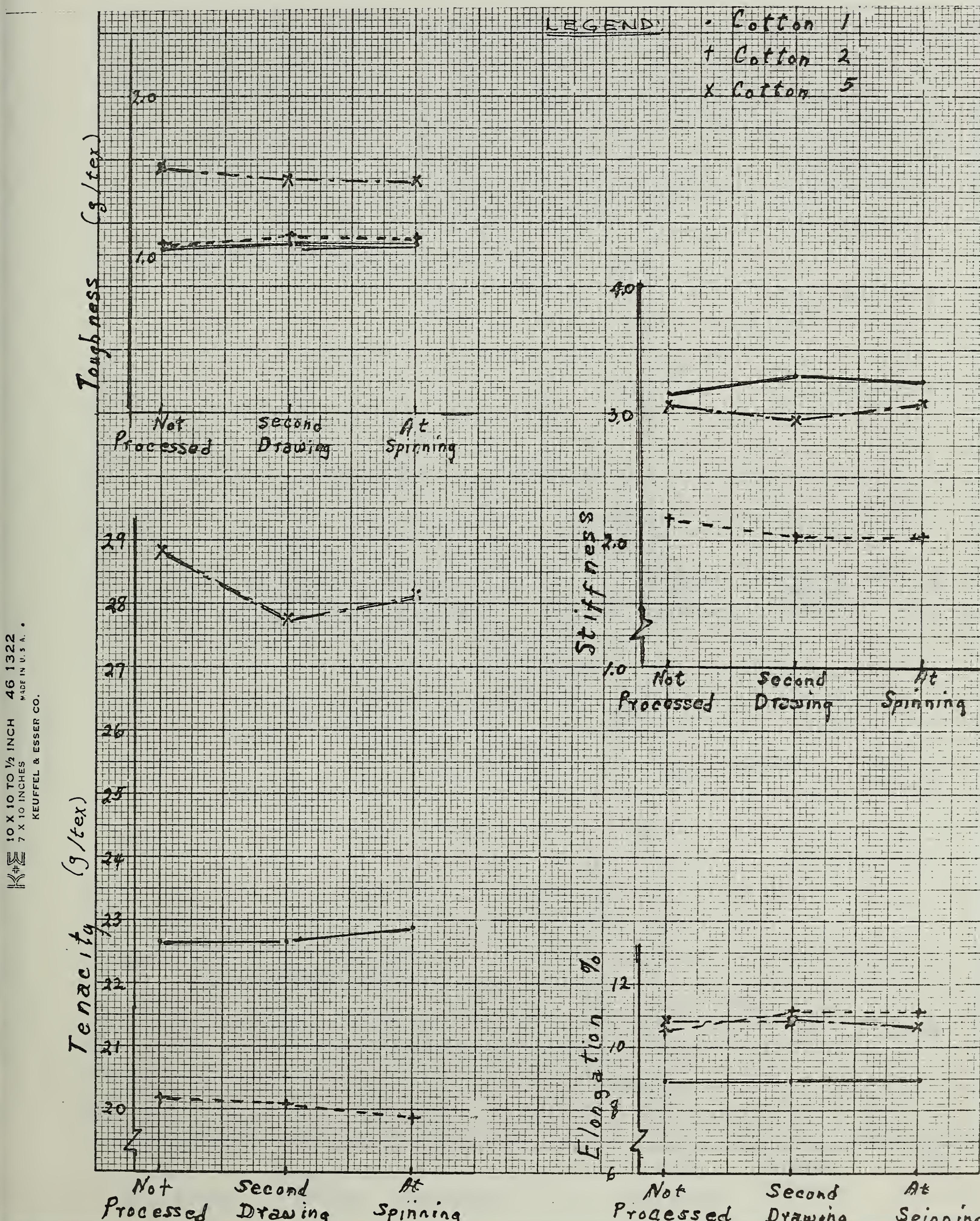


Figure E-2. Variety-processing stage interaction as determined by length uniformity, ACV, 50% span length and 2.5% span length.

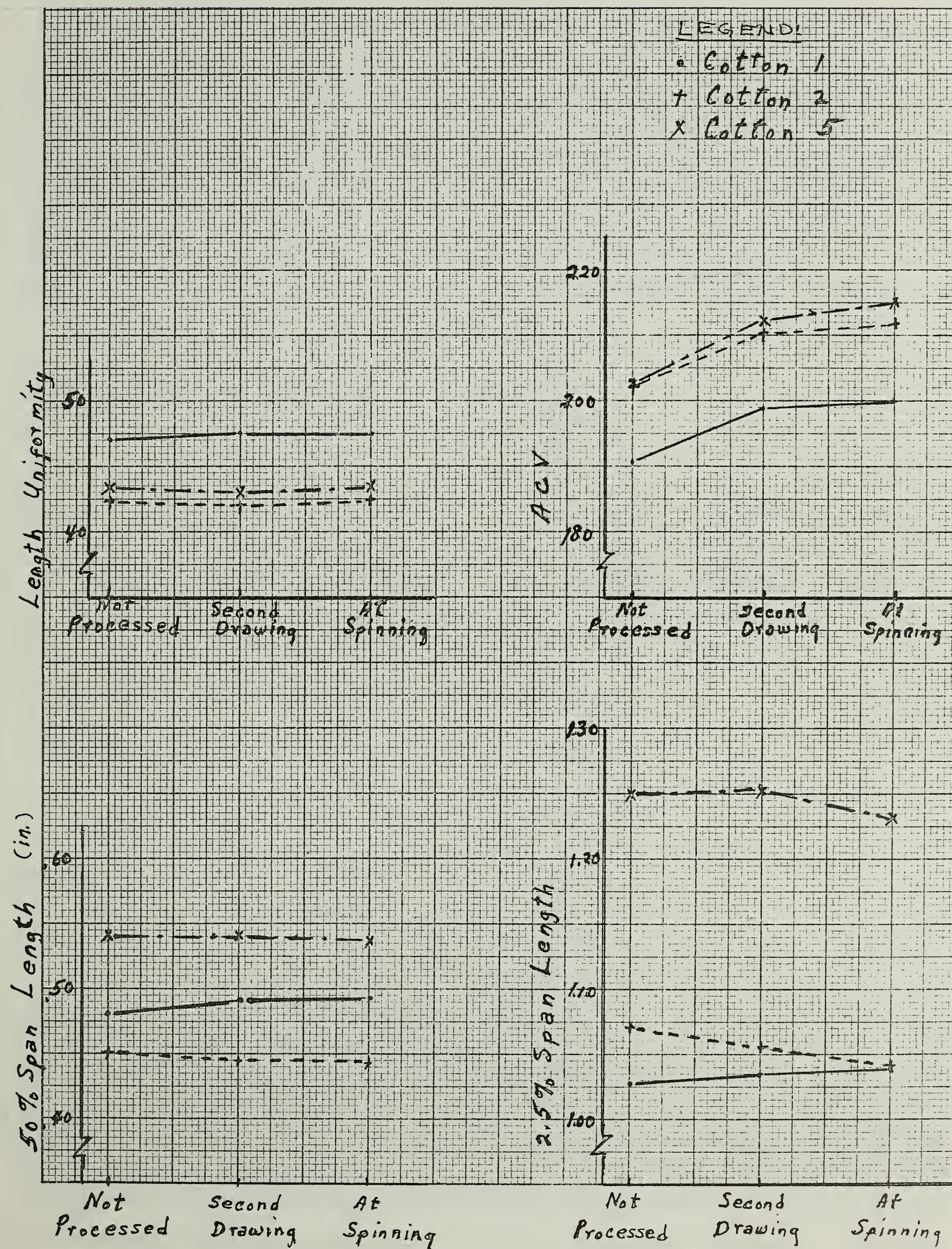


Figure E-3. Modification-processing stage interaction as determined by toughness, stiffness, tenacity and elongation.

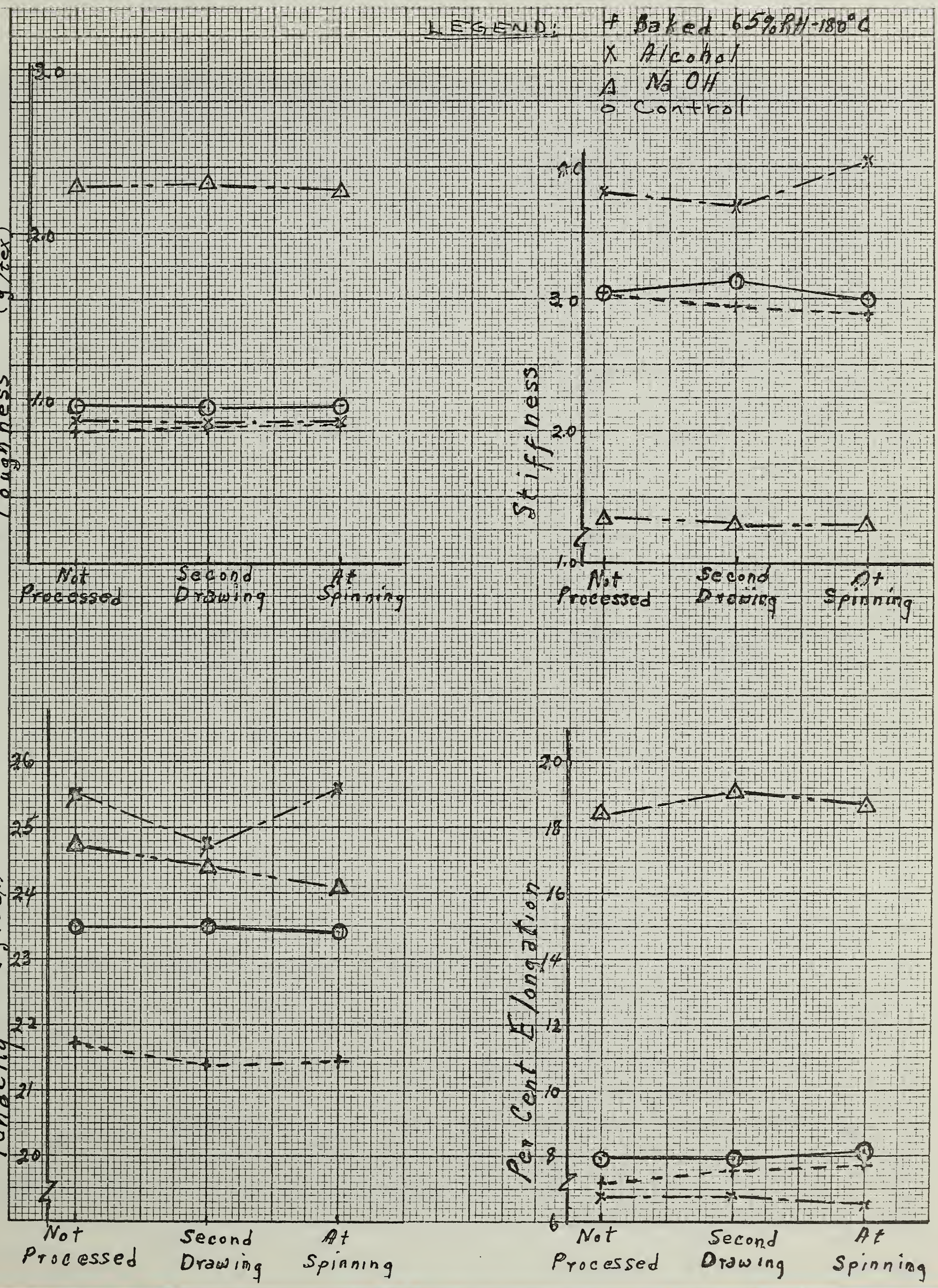
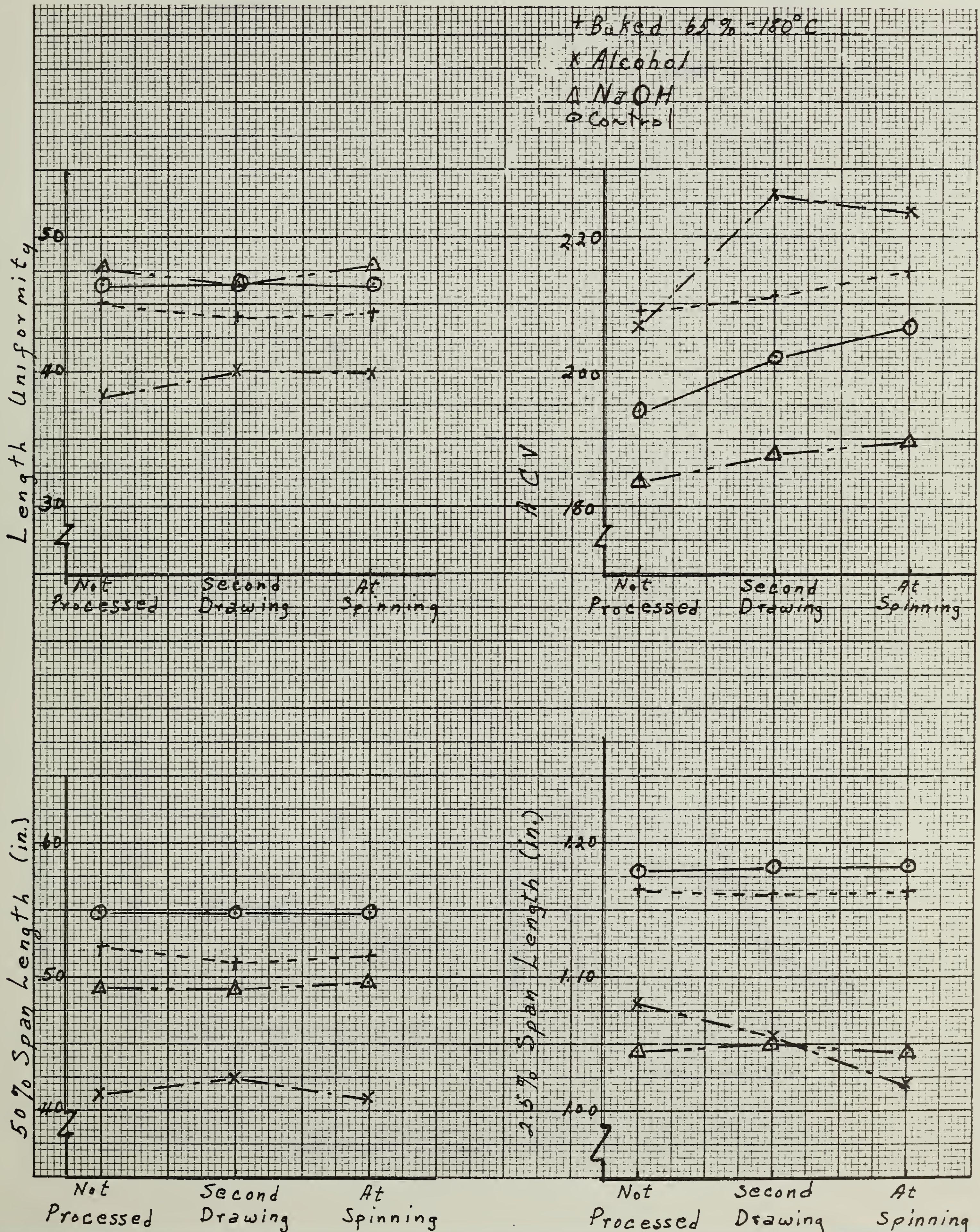


Figure E-4. Modification-processing stage interaction as determined by length uniformity, ACV, 50% span length and 2.5% span length.



Variety

- C-1 Cal 7-8
+ C-2 Deltapine SL
× C-5 Pima S-2

Modifications

8 Control
5 65% RH - 180°C
6 Alcohol
7 NaOH

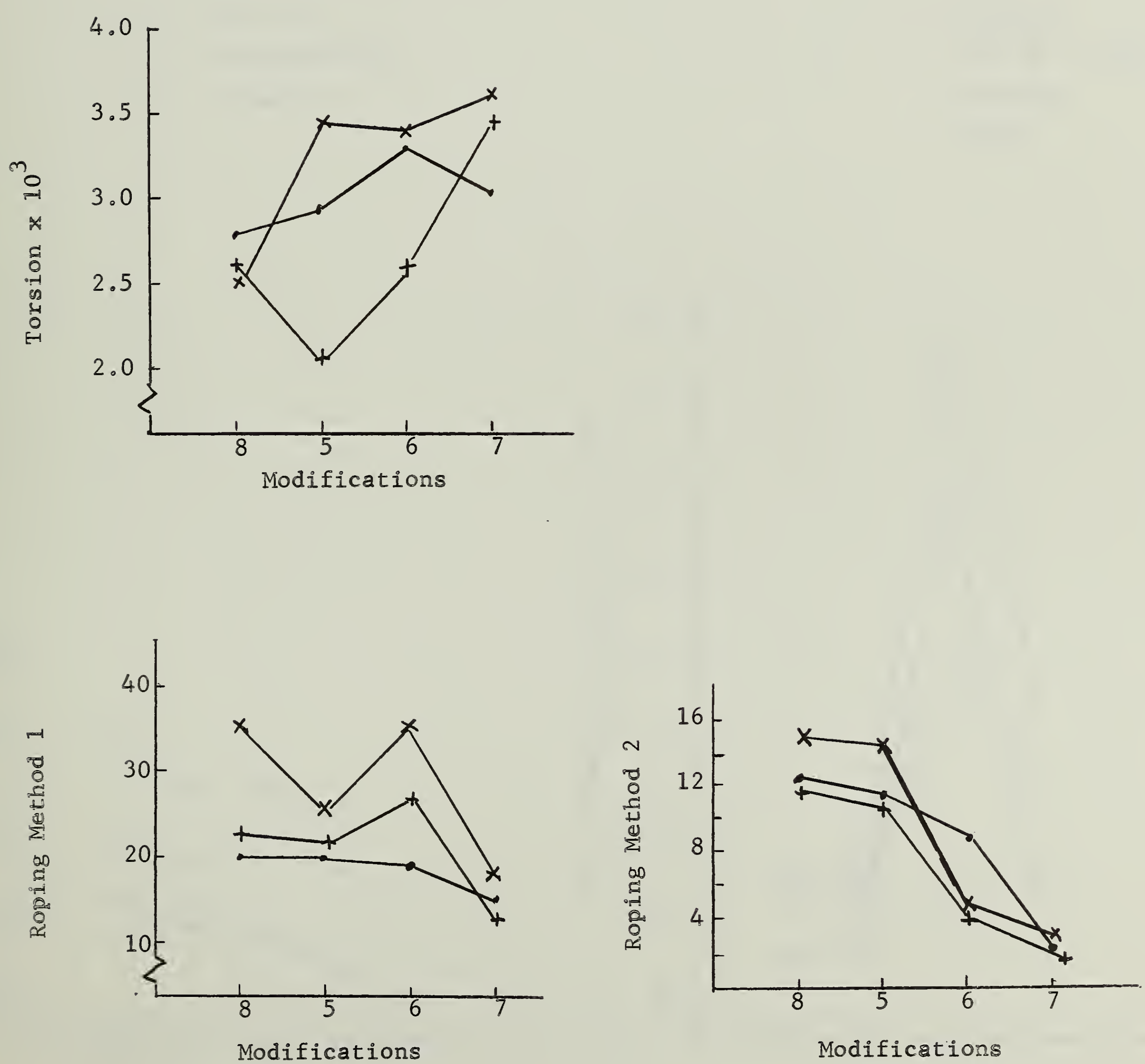


Figure E-5. Variety-modification interaction as determined by roping and torsion.

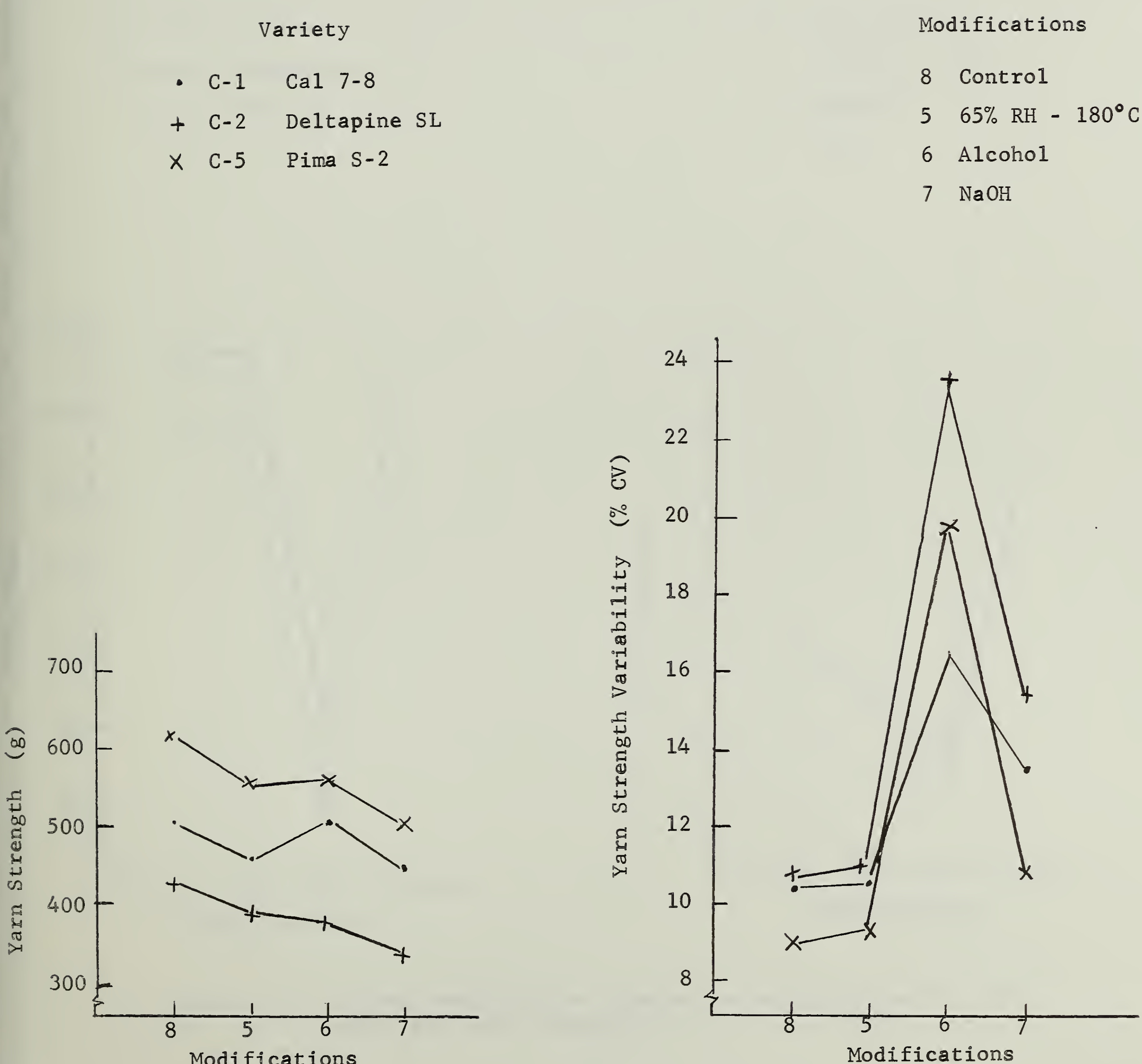


Figure E-6. Variety-modification interaction as determined by yarn strength and yarn strength coefficients of variation.

Variety

- • C-1 Cal 7-8
- + C-2 Deltapine SL
- x C-5 Pima S-2

Modifications

8 Control

5 65% RH - 180°C

6 Alcohol

7 NaOH

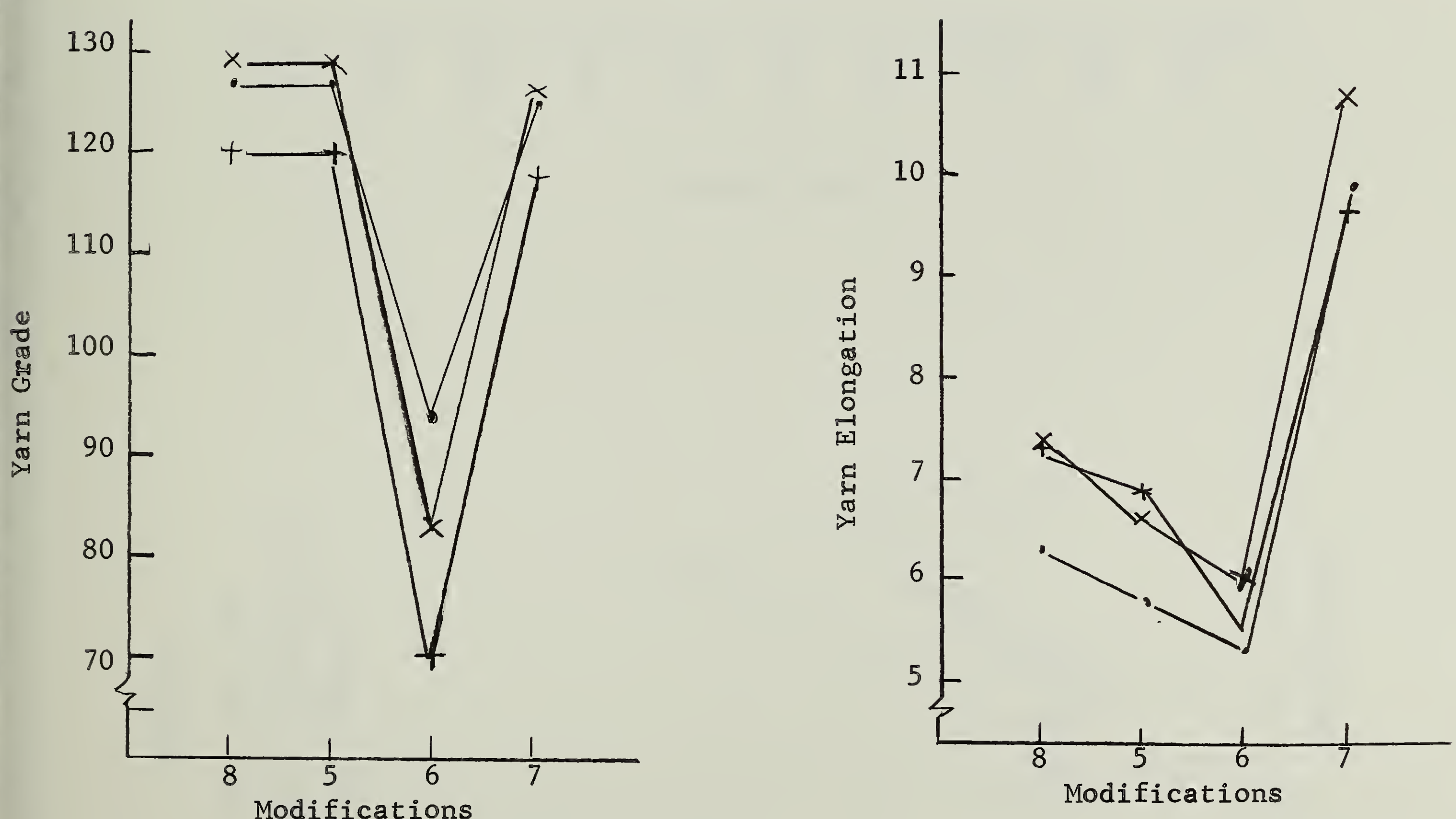


Figure E-7. Variety-modification interaction as determined by yarn grade and yarn elongation.

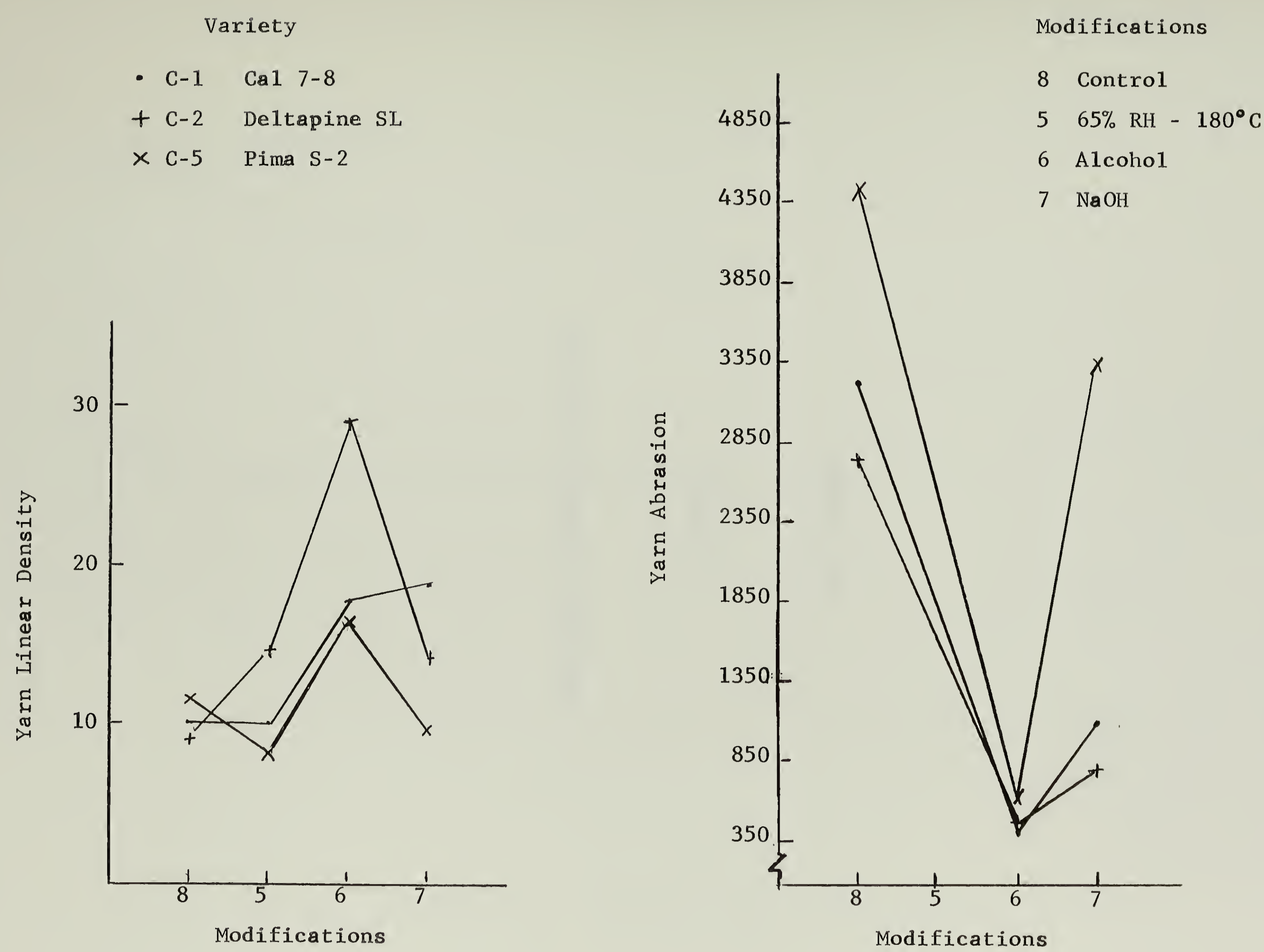


Figure E-8. Variety-modification interaction as determined by yarn linear density and yarn abrasion.

SECTION XIV

APPENDIX F

DRAWINGS OF SPECIAL EQUIPMENT

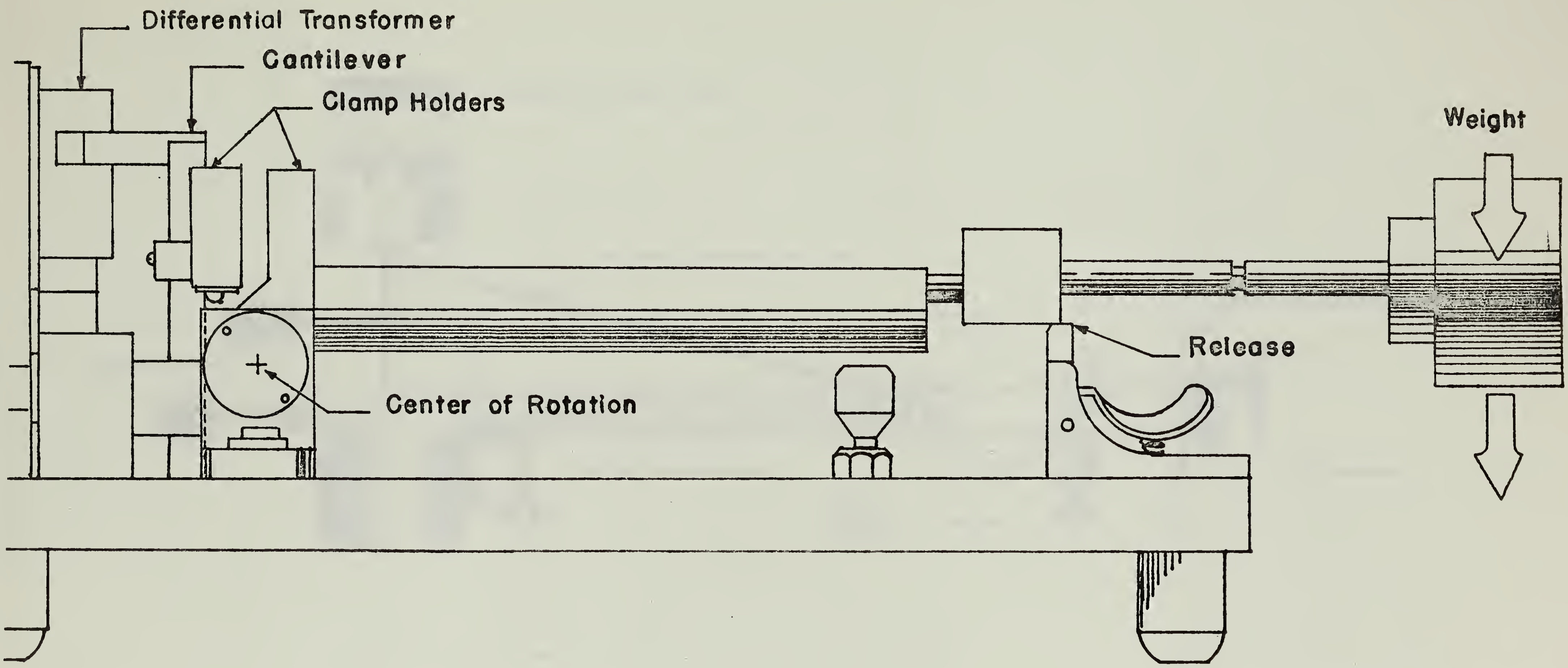


FIGURE F-I IMPACT BREAKER

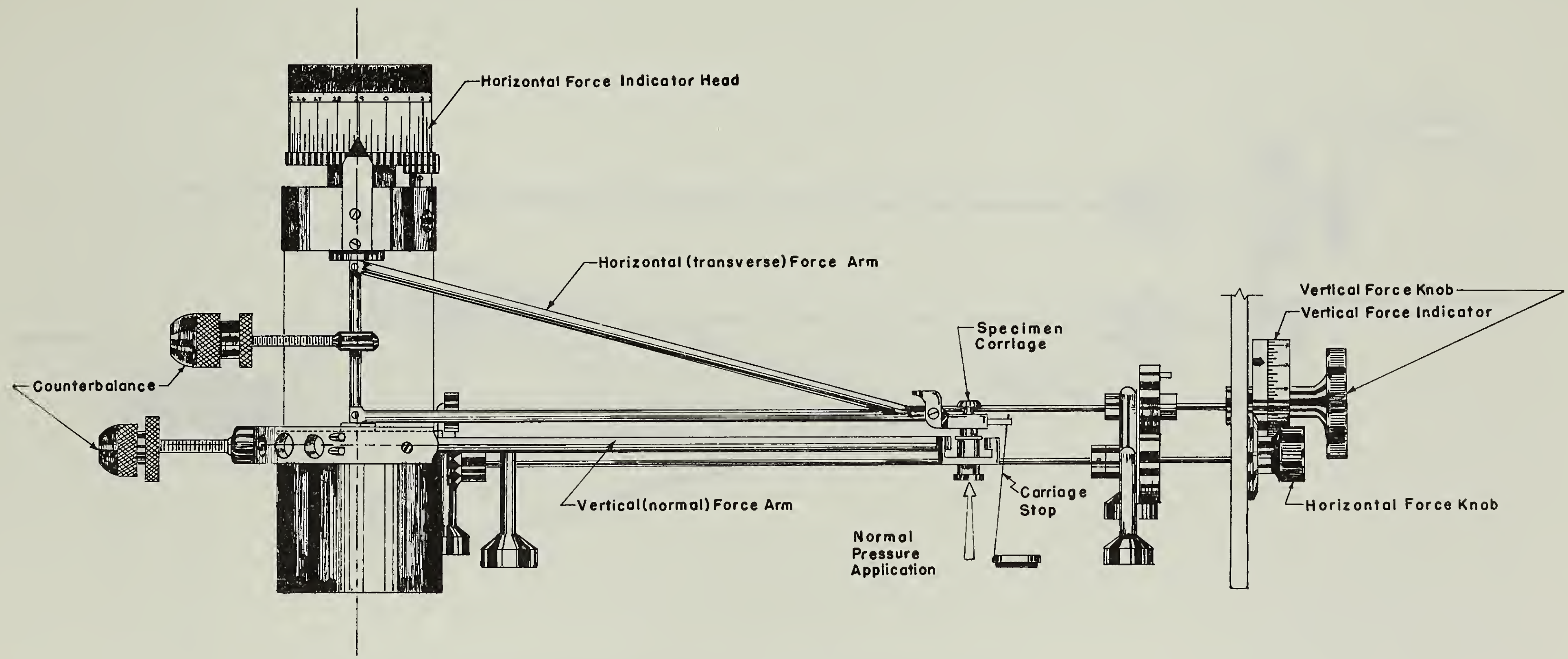


FIGURE F-2 FRONT VIEW- BASIC ELEMENTS OF THE FRICTION TESTER

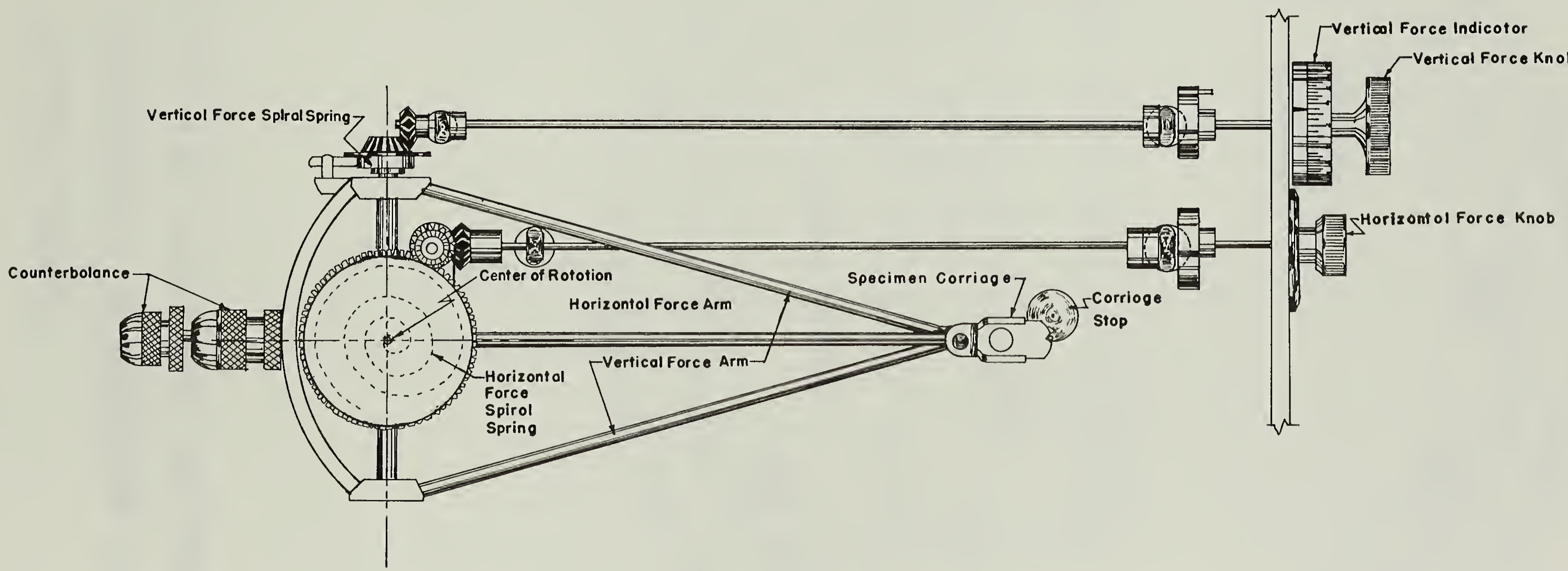


FIGURE F-3 TOP VIEW- BASIC ELEMENTS OF THE FRICTION TESTER

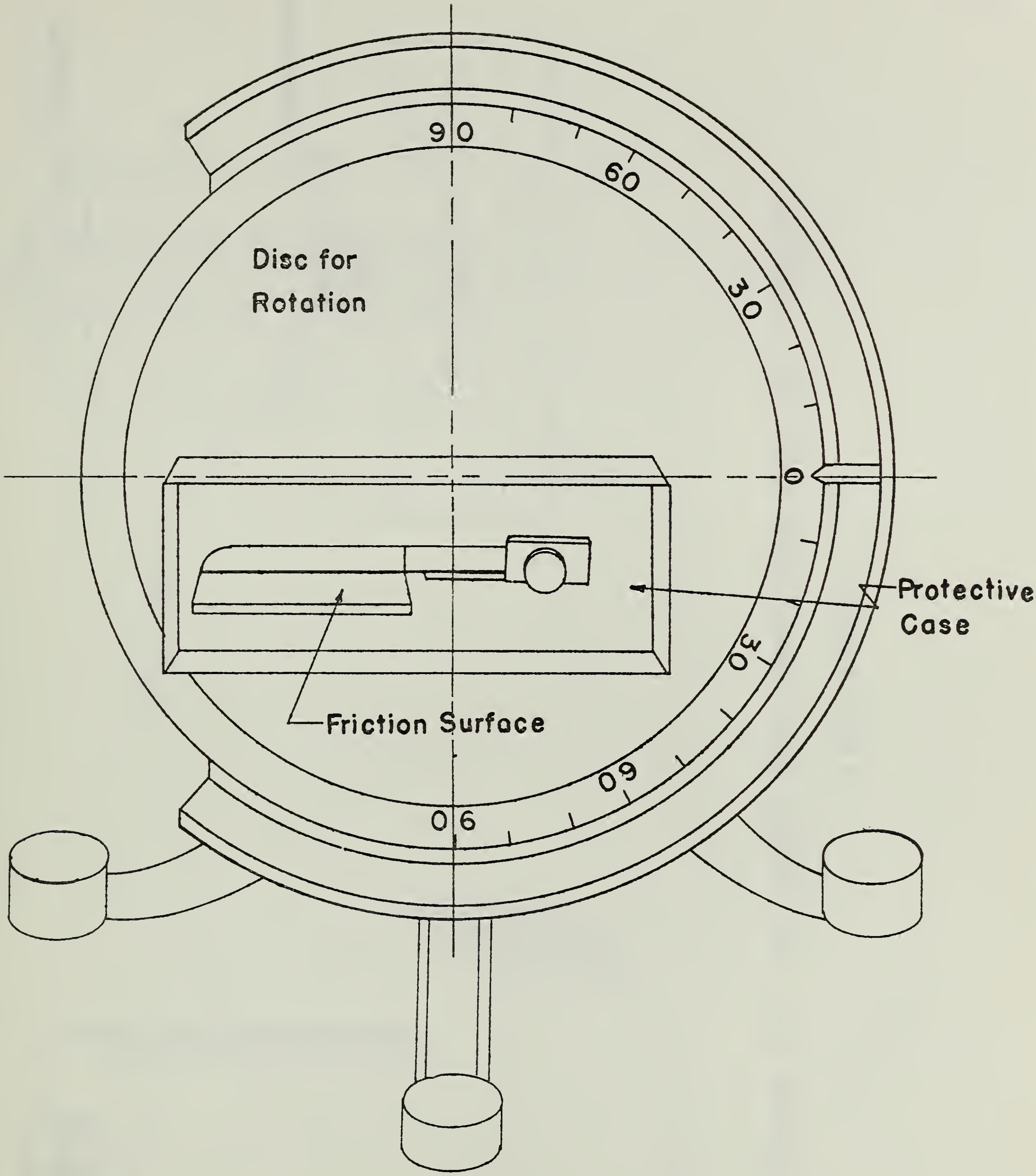


FIGURE F-4 DISC AND PLANE FOR DETERMINING COEFFICIENT OF FRICTION OF COTTON FIBERS

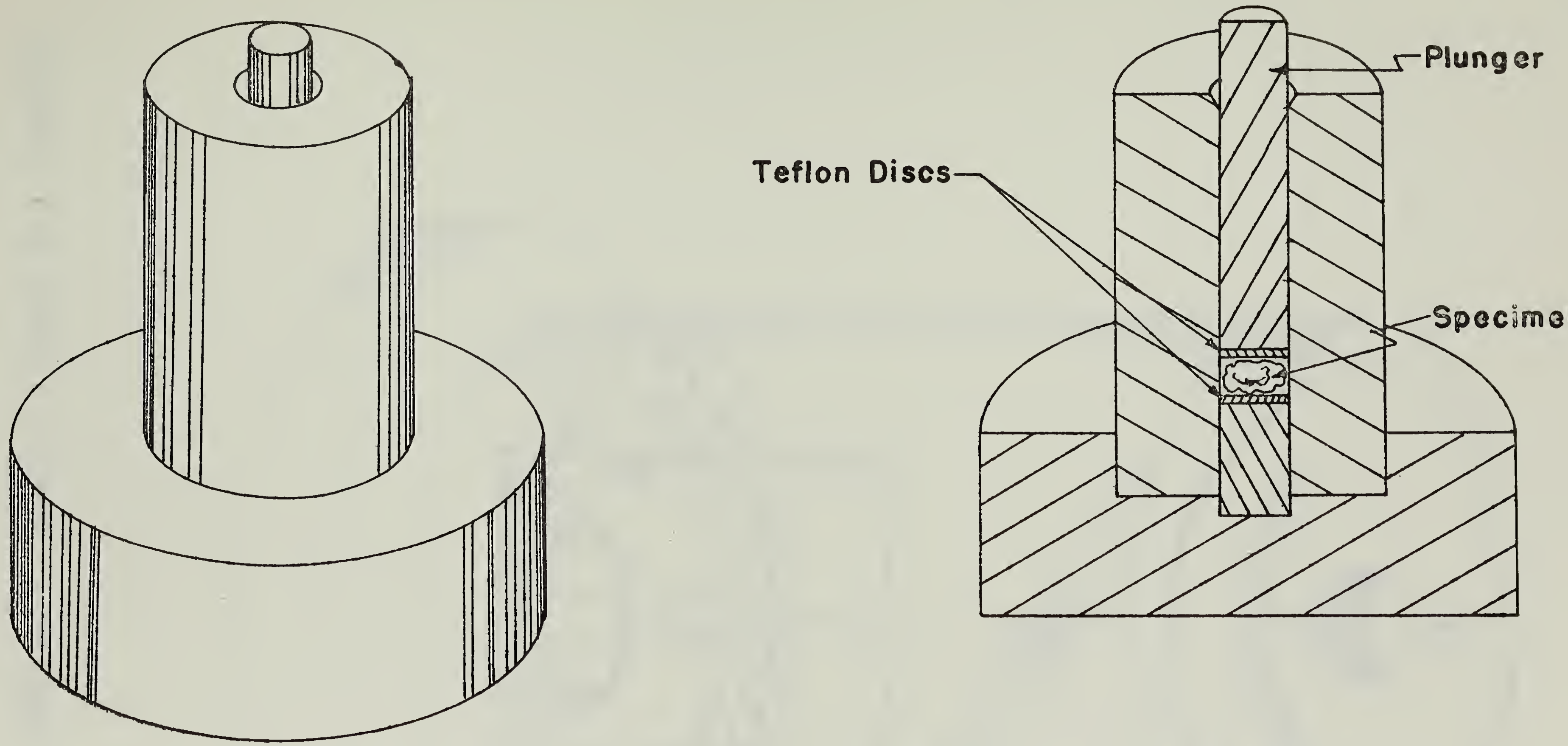


FIGURE F-5 CYLINDER FOR CRUSHING COTTON FIBERS

(full scale)

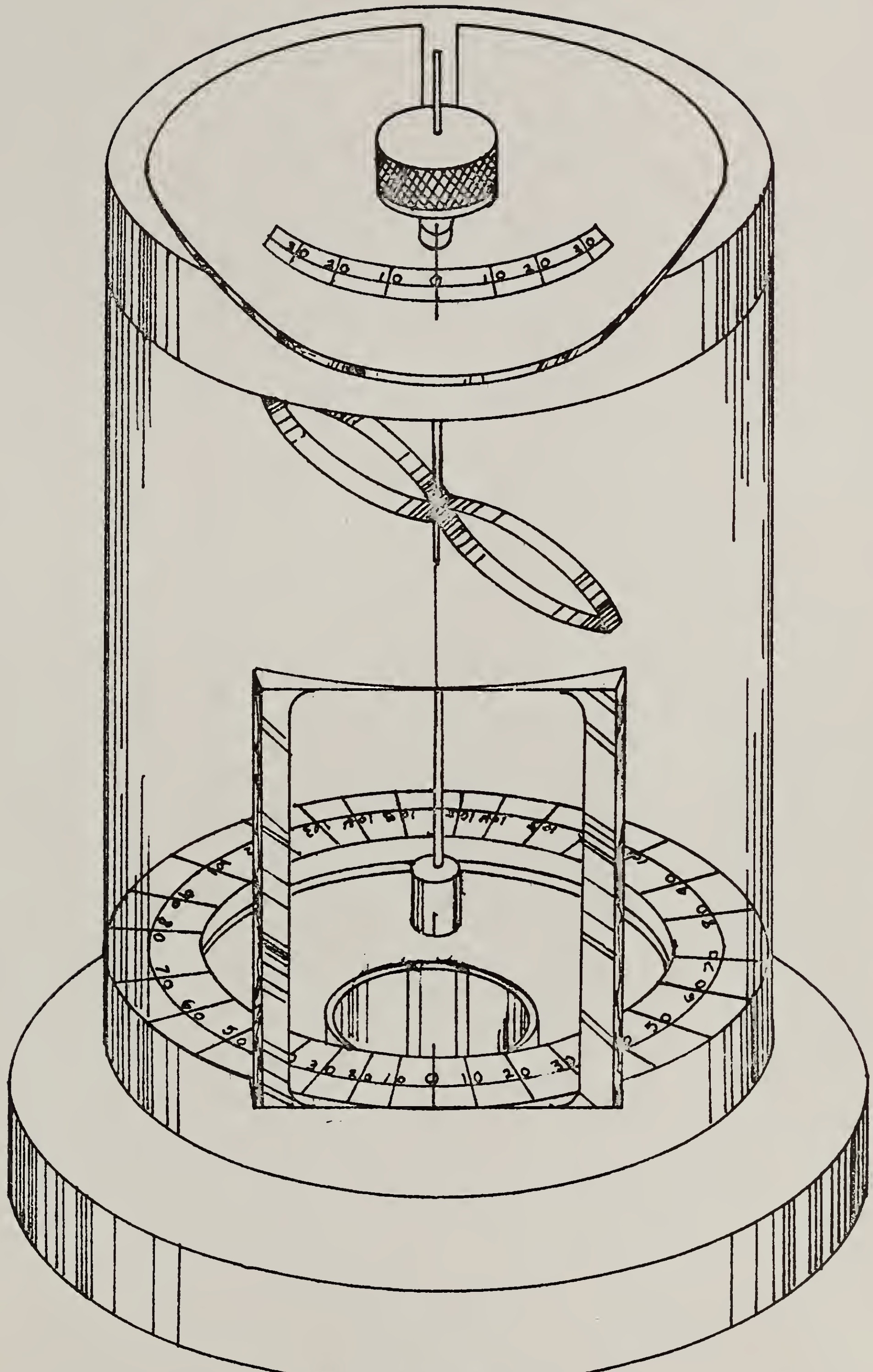


FIGURE F-6 SINGLE FIBER TORSION DEVICE